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ABSTRACT

THIS STUDY EXPLORES THE POSSIBILITY THAT A MODEL DEVELOPED BY J.E.L. FARRADANE OF LONDON MAY AID IN DEVELOPING A TEACHING STRATEGY FOUNDED UPON SOME OF WHAT IS KNOWN ABOUT CONCEPTUALIZATION, AND PROVIDING DIAGNOSTIC PROCEDURES TO APPLY IN DETERMINING A FRAME WITHIN WHICH TO DEVELOP A PROGNOSIS TO ADHERE TO IN DIRECTING SPECIFIC CONCEPT DEVELOPMENT. A PICTURE-AND-WORD-DESCRIPTION INSTRUMENT, USING TWENTY CONCEPTS RANGING FROM FIRST THROUGH SIXTH GRADE DIFFUCULTY, WAS INDIVIDUALLY ADMINISTERED TO 318 STUDENTS, RANDOMLY SELECTED FROM A STRATIFIED POPULATION. SCALOGRAM ANALYSIS INDICATED THAT "THE PUBLIC TEST OF THE FORMATION OF A CONCEPT" WILL NOT ENABLE A TEACHER TO DETERMINE WHETHER A STUDENT HAS ATTAINED CLARITY OF A GIVEN CONCEPT. THE COEFFICIENT OF REPRODUCTIVITY VALUE FOR THE SUGGESTED MODEL IS .83, ACCEPTABLE FOR SUSTAINING INTEREST UNTIL ADDITIONAL DATA ARE OBTAINED. DATA TABLES AND A DESCRIPTIVE COPY OF THE INSTRUMENT ARE INCLUDED. (AUTHOR/CJ)

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Albuquerque, New Mexico 87106

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Great appreciation is felt for those people like Evelyn Short, Karen Guest, and Oscar Mora, who said, "Let me serve."

ABSTRACT

AN EXPLORATIONAL STUDY
IN
CONCEPT CLARITY
USING
FARRADANE'S NINE STAGE MODEL

Leon Edgar Williamson, Ed.D.
Curriculum and Instruction
The University of New Mexico, 1969

The purpose of this study was to explore the possibilities Farradane's nine stage model (which suggests nine relations essential for increasing concept clarity) may offer in developing a strategy to apply in concept teaching. That is, a strategy which would permit teachers to diagnose student level of concept attainment, to establish a frame within which to develop a prognosis, and to determine enough direction to teach diagnostically in achieving the goals set in the prognosis.

The study was conducted by selecting twenty concepts from three sets of elementary science books. For each concept selected, chromatic presentations representing the nine relations in the Farradane model plus three foils for each relation were developed. The instrument was administered individually to one hundred three first grade subjects, one hundred nine third grade subjects, and one hundred six sixth grade subjects. These subjects attended four Las Cruces, New Mexico elementary schools. The subjects were randomly selected from all the first, third, and sixth grade students who met the following criteria: (1) English as a native or first language; (2) a northern European cultural heritage; and (3) an annual disposable family income at or above $6,500.

Subjects' responses were run through factor and scalogram analyses. Factor analysis revealed that, for combined subjects' performances, all correla-

tion coefficients in bivariate comparisons were significant at the .01 level of confidence. For combined subjects' performances one eigenvalue accounted for about sixty-six per cent of the factors responsible for subjects' performances on the instrument used to test the Farradane model. This strongly suggests that the model has one factor and could be better expressed on a unidimensional scale. Results from factor analysis for subject performance by grade levels were not as decisive for there being one factor largely responsible for subjects' responses.

Scalogram analysis confirmed the idea of a unidimensional scale. The nine conceptual relations were put in a sequence from easiest to most difficult (based upon subjects' response patterns), and a scale was obtained which had a coefficient of reproducibility value of .83. Although this .83 falls short of the .90 most authorities would require for a scale, it is high enough to warrant further interest. Improvement in the rather untested instrument used in the study could easily result in a coefficient of reproducibility value higher than .90.

For combined subjects' performances, scalogram analysis revealed the following sequence of conceptual relations when ordered from the easiest to the most difficult: Concurrence, Distinctness, Appurtenance, Dimensional, Self-activity, Equivalence, Reaction, Association, and Evaluation as defined by Farradane. A superficial set of definitions of the nine relations is:

1. Concurrence: Recognizing members of a concept.
2. Distinctness: Recognizing what is not a member of the concept.
3. Appurtenance: Being aware of unique characteristics which results in placing members in the concept.
4. Dimensional: Knowing the range in sizes for members of the concept.
5. Self-activity: Understanding an act or activity peculiar to members of

the same concept.

6. Equivalence: Recognizing two or more members of the same concept.

7. Reaction: Being aware of the effect one concept has upon another.

8. Association: Seeing a cause and effect relationship between two or more concepts.

9. Functional Dependence: Understanding what members of a concept rely upon for continued existence.

This study offers a strategy teachers can follow in directing concept development, which meets the criteria of containing diagnostic possibilities, insights for developing a prognosis, and directions to follow in achieving the goals set in the prognosis. Also, results of the study would be meaningful to developers of educational materials.

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CHAPTER I

GENESIS OF THE PROBLEM

"Teachers are essentially involved in teaching concepts, yet few teachers understand concept formation and its place in mental growth." (23, p. 31) This is an educational problem since the learning of new concepts is perhaps the single most important kind of learning; in fact, concepts are part of every subject taught in school. (22, p. 54) Concepts are important because they provide orderly, economical classification of phenomena in the social and physical world. (22, p. 55) Garrison wrote, "The number and type of concepts a student has attained profoundly affects his success or failure in learning." (10, p. 258) But few teachers are aware of any technique based upon querying procedures which would assist them as teachers in determining the extent to which students have attained a concept while directing the students toward further developmental clarity of the concept.

The lack of instructional techniques beyond that of determining student ability to respond correctly and reliably to positive and negative instances of a given concept may be due in part to the lack of agreement on a definition for concept. In 1890, James said, "Conception is the most important of all features of our mental structure." (15, p. 300) Many may agree with this assertion but fail to agree on what is mentally created in the process of conception or the procedure to be followed during the creation. Therefore, disagreement on what a concept is and how it comes to be leaves educators in a quandary when attempting to develop instructional theory and techniques for the teaching of concepts.

In 1897, Ribot defined a concept as ". . . a habit, an organized memory." (22) To Price, it is ". . . a recognitional capacity. . ." (21) For Bruner, "The working definition of a concept is the network of inferences that are or may be set into play by an act of categorization." (3, p. 244) By use of the word network, Bruner implies that a concept is a relationship. T. S. Kendler defines a concept as being a ". . . common response to dissimilar stimuli." (18, p. 447) Humphrey, like Kendler, describes a mental activity for his definition of a concept when he writes it is ". . . the activity whereby an organism comes to effect a constant modification towards an invariable feature or set of features occuring in a variable context. (13) Vinacke defined concepts as ". . . cognitive organization systems which bring pertinent past experience to bear on a present object or situation." (31, p. 527) To Russell, concepts are one type of the materials of thought as distinct from the processes. (23, p. 645) H. H. Kendler believes Piaget's work with concept formation precludes any satisfactory working definition for the term concept. (16, p. 222) Piaget and his colleagues have concentrated upon naturalistic observations in studying the cognitive life of children. Piaget believes concept formation and concept modification result from an organism cognitively seeking to establish and re-establish what he (Piaget) calls equilibration; that is, the function of behavior is to maintain a state of equilibrium between the individual and the environment. It is in the maintenance of this equilibrium that concepts are cognitively formed and modified.

These definitions and descriptions of mental activities are lacking uniformity in stating specificity. A dichotomy is also revealed between those definitions and descriptions which regard a concept as a dynamic process for scanning perceptual data in the light of past experience, and those to which a concept is a "thing," a piece of mental furniture, a product of reification. (34, p. 2) Isaacs comments that ". . . each of these so-called concepts is in truth a complex psychic structure built up by children over the years by slow stages . . . as these structures reach mature form, they increasingly integrate into a single mobile operational organization which basically controls all the pattern and scope of our active life." (14) Gega suggests a concept is the result of a natural tendency of the mind to develop cognitive structures for use in scanning perceptual data which initiates the classification of phenomena in the environment. (11, p. 40) These mental structures make categorization possible which results in assigning properties to phenomena in the environment. Properties of concepts are based upon: (a) point of references with respect to all other concepts; (b) accuracy -- a dog for a dog, not a cat; (c) the consistent combination of the objective properties of the object and the subjective impressions of the individual.

Although many sapient remarks about concepts have been made and a plethora of studies on concept learning conducted, in 1964, Carrol wrote:

> One would have thought that volumes would have been written on the subject /concept teaching/, but apart from such brief treatments as those of Brownell and Hendrickson, Serra, Levit, and Vinacke, for example, one searches the literature in vain for any comprehensive treatment of concept teaching. One is reassured that there are gaps to be filled. (5, p. 178)

Wallace is even more emphatic about the lack of relevancy which past research has contributed to the subject of concept teaching. He wrote:

> It is a sad commentary on the effectiveness of our methods of inquiry that after some eighty years of psychological investigation and a discontinuous history of forty years of laboratory experiment, our fund of accepted knowledge on the subject of conceptualization comprises so little of consequence that it is hardly worth compiling. (34, p. 198)

Are educators more responsible for the lack of a strategy for teaching concepts than any other professional group? Commenting on interest in the concept, Carroll wrote, "Concept is almost anybody's oyster: it has continually been the concern of the philosopher, but has received generous attention from psychology." (5, p. 179) But the few and brief existing treatments on the literature of concept teaching indicate educators have shown less interest in conceptualization than have philosophers and psychologists. However, there are some educators who are interested. Stauffer is one of them. He wrote,

> Although many concepts may emerge on a fortuitous and salutary basis among children in particular, the objective of acquiring knowledge (the sole objective of education) demands a planned and systematic approach to the construction of concepts. Mental construction work, or the building of concepts, is the primary task of the learner and, to be accomplished effectively, requires the direction of a skilled teacher. (25, p. 36)

Unfortunately, colleges of education are not producing teachers skilled in directing the development of concepts. Often it seems as if too many educators believe that since philosophers deal with ideas and psychologists with rats, educators are precluded from having or showing intense interest in conceptualization because they, educators, deal with children rather than ideas and rats.

Since educators per se have not attempted to contribute to the understanding of conceptualization and to the development of instructional techniques to apply in teaching concepts, a brief survey of what psychologists have been doing will be given. The attention psychology has given concept has been affected, in most part, by stimulus-response (S-R) learning theory or a modification thereof. In psychology, the study of concept learning has taken two directions. These two directions are discussed by H. H. Kendler. He describes one direction as being interested in the discovery of systematic relationship between stimulus events and a common response. Attention for this sort of interest is focused primarily on the stimulus-response relationship. The second direction is represented by the major interest being directed at the mediational mechanism responsible for concept behavior. The internal cue instead of the association becomes the main focus of attention. (16, pp. 211-233) More succinctly:

> One of the major differences between stimulus-response correlationists and mediational theorists is that the former are interested in concepts as associations and the latter is concepts as cues. The result is that the former have been more concerned with concept formation, while the latter are primarily interested in concept utilization. (16, p. 229)

Klausmeier, et al, in commenting on the designs of the experiments of those psychologists concerned primarily with the stimulus-response relationship in concept learning, wrote: "The designs of the experiments conducted by the . . . /stimulus-response psychologists/ are good; however, the results appear to have only modest applicability to the learning of concepts in everyday situations." (15, p. 3) H. H. Kendler suggests that the stimulus-response approach to studying concept learning largely ignores such problems as concept utilization, concept modification, and level of abstraction of concepts. He also suggests that operationally specifying a concept as a common response to dissimilar stimuli fails to distinguish it from ordinary discriminations and responses to generalized stimuli. (16, pp. 211-236)

The basic idea in the mediational mechanism approach is that there are mediating responses between the intital stimulus and the terminating response. (29, p. 154) Psychologists who accept the mediating response theory are not in agreement as to what a mediating response is. Osgood suggests that a mediating response is a detached component of the overt response. The mediational approach often makes use of what is called a "reversal shift." A reversal shift is a change within the same dimension such that the values to be responded to remain the same but the responses are inter-changed. A nonreversal shift which is common to stimulus-response studies is a shift to a different dimension such that the first correct dimension now becomes irrelevant. (29, p. 155)

Both the orthodox stimulus-response approach and the more modern mediational mechanism approach make use of and depend upon the positive-negative instances of a concept to determine when a subject has attained a concept. Carroll says, "The public test of the formation of a concept is the ability to respond correctly and reliably to new positive and negative instances of it . . . " (5, p. 181) The reliance upon the test of responding correctly and reliably to new positive and negative instances of a concept to determine if it has been acquired makes use of only the first level of cognitive operations as defined in Bloom's Taxonomy of Educational Objectives Handbook I: Cognitive Domain. An assumption stated by T. S. Kendler which is held by learning psychologists may be responsible for the inquiring into concept learning never going above the first level of cognitive function as defined by Bloom. The assumption as stated and explained by Kendler is:

> There is an implicit assumption common to all learning psychologists that the processes uncovered by experimental investigations are common to all organisms. It is presumed that there is a generality to the laws that relate the organism to his environment that spreads across phylogenetic and ontogenetic divisions and that there is a commonality to the learning process from its simplest to its most complex manifestations. (17, p. 53)

Although Kendler states that ". . . when we become concerned with 'thinking' we find we must leave these safe shores and grapple with the complexities presented by differences between species and differences between age levels . . ." (17, pp. 53-54), this recognition as of yet has not lead to new approaches for educators' use in directing students' attainment of concepts. If one were to contrast the method of concept teaching suggested by Sarah Louise Arnold in 1899 to the suggested method of concept teaching in 1969, it would appear that few, if any, advancements have been realized. The following "Lesson Upon the Cow" is taken from Arnold's book, Reading: How to Teach It, copyrighted 1899.

Lesson Upon the Cow

To precede or accompany Reading Lessons which refer to the Cow (in lowest grades).

1. Find out what the children know about the cow.

Every new lesson should be built upon and fastened to the children's past experience. If they have no knowledge of cows, we must introduce the subject accordingly. If they have always known them, the lesson will be merely a review, because the foundation will have been prepared. If the children live in the country and know the common animals, proceed at once to definite questions which will arrange their knowledge and help them to express it:

Where have you seen cows? What do you know about them -- their size, color, the head, ears, legs, feet, tail?

How large are they, as compared with the horse, dog, cat?

Compare the covering with that of the horse, dog, cat. Compare the parts with the corresponding parts of those animals.

Describe the horns. Why do cows have horns? What use do they make of them?

Describe the ears. Where are they? Does the cow move them? The ears of the dog, cat, cow, horse are movable; our are not. Why?

Compare the cow's nose and mouth with those of the cat or the horse.

Does anyone know anything about the cow's teeth? What does she eat? What kind of teeth does she need?

Tell the children about the chewing of the cud.

Of what use to the cow is the long tail with its brush at the end? Who has seen her use it? Would a short tail serve as well?

Who knows something about the cow's foot? Who can draw a picture of the cow's footprint?

Of what use are cows to us? What kind of stall, what kind of bed, what food, water, pasture, should they have? Describe a pasture that you would like if you were a cow. Describe a barn that you would like if you were a cow.

How ought we to treat animals? Is it right to forget their wants when we have the care of them?

Every lesson upon animals should help the children to realize more fully their obligation to properly care for them. Sympathy for animal life ought to be developed through the reading and language lessons. Interest in animal life is always present in children. The questions suggested above cannot be answered at once, by any ordinary class of children. Many who are familiar with cows in general will be unable to answer them definitely. But the questions will lead them to more thoughtful observation, after which they can report in another lesson. Sometimes the subjects may be distributed, different groups of children being held responsible for the answer to a certain question.

2. Direct outside observation, in order to get new knowledge.

It is entirely feasible, in many schoolrooms, to make the study of the cow the subject of a field lesson. The children may be taken in groups to a farmyard, a pasture, or a stable, where a cow may be observed and studied. Such lessons have ceased to be formidable, since they have become so common. The need of these visits is revealed by the children's vague answers. Nothing but definite observation of the real thing will open their eyes, and make the words in their lesson full of meaning.

There are many city children who have never seen a cow. If it is impossible to take them to a real cow, excellent pictures should be substituted. Many of the questions suggested could be answered by pictures. It must be remembered, however, that the picture tells us, who have had the real experience, much more than it tells to a child who has never had the experience. It is not strange that a boy who has never seen a real cow should imagine that animal to be six inches long, the size of the cow which he has known from pictures in the lesson. Emphasize the fact of the size. Allude to the picture as a picture only. Have the children show by their hands how high a cow would be, how long, how wide its head, etc. By such means, help to vivify the mental picture which is suggested to the children by the lesson. If the pictures are the only avenue through which they learn about the cow, do not attempt to give as much information as would naturally be associated with the real observation lesson. Remember that the amount of knowledge which the child gains is not proportioned to the number of facts which the teacher enumerates. He will intelligently appropriate those which his observation and thought have helped him to understand.

> As has been said before, this truth determines the value of the reading lesson to the child, and necessitates the associated lessons, which supplement his experience and enables him to bring to the lesson a mind furnished with appropriate ideas.
>
> 3. Tell the children simple facts which they cannot find out for themselves.
> There are many facts associated with the cow which the children can only know through others: the use of the horns, of the bones, the hair, etc.; the manufactures; the reason for the cud chewing; the making of butter and cheese. The writer has known classrooms in which milk was skimmed, the cream churned into butter, and the butter eaten by the children. The quantity, of course, was small, but the process was very real and very interesting. This happened recently in a kindergarten in a large city. There were only three children in the class who had ever seen a cow. It is hardly necessary to say that the lesson followed a visit to the cow.
>
> 4. Reinforce the lessons by stories.
> Stories about cows, or descriptions of certain animals. Perhaps the pets which we have known will add interest to the lessons.
>
> 5. Collect pictures of cows for comparisons and descriptions.
> In almost any district the children will be able to help in making collections of pictures which illustrate the language and reading lesson. These pictures can be obtained from newspapers, magazines, advertisements, and various other sources. Every child who helps to swell the collection will feel an added interest in it. The collection will be valuable in proportion as it is carefully arranged and thoughtfully used by the teacher. If the cards are neatly mounted upon separate sheets which contain the name of the contributor, and distributed among the children for observation and comparison, it will prove really helpful. Through the comparison of the different pictures many facts will be developed, suggested by the children's comments or questions. Such teaching will be sure to fit the need of the children.
>
> These suggestions will be modified and arranged by any teacher who desires to use them. They may help to point the way for those who are not entirely familiar with this phase of their work, and so lead to better things. (1, pp. 139-147)

In 1953, Serra wrote an article, "How to Develop Concepts and Their Verbal Representation," which basically emphasized vocabulary rather than conceptual development. Too often, words are accepted as being synonymous with concepts.

They are not synonymous. Concepts are the seeds from which meaningful words (language) may sprout. The seed and the sprout are not synonymous. A concept can function without a word; a word without the foundation of a concept is meaningless. Stauffer gives an excellent discussion on vocabulary versus concept in his book, Teaching Reading As a Thinking Process. Stauffer suggests the following ways in which concepts and vocabulary differ:

> One of the subtle differences between a person's vocabulary and his stock of concepts is a semantic difference as exemplified by the differences noted by Brown between children's vocabularies and adults'. Not only is there a 'concrete-abstract' difference, but also a 'superordinate-subordinate' difference. As Horn points out, to acquire constructs such as the Industrial Revolution or the effect of the sun's position upon temperature presupposes the making of many subordinate constructs.
>
> Vocabulary might be distinguished from a stock of concepts by the commonality of a word's semantic dimensions. A car may be distinguished from a truck on such a basis much more readily than subclasses of Chevrolets.
>
> Vocabulary can be measured by a check on a person's ability to note the more obvious likenesses and differences and produce a synonym or antonym. This knowledge is superficial when compared with a knowledge of concepts that discriminates carefully among synonyms, that can be supported by clear comparisons between words of a common denotation, and that distinguishes the differences in implications.
>
> A person's hearing, speaking, reading, and writing vocabularies may not be in perfect ratio to his thorough understanding vocabulary which is really based upon concept attainment. (25, pp. 138-39)

Even though the Serra article emphasized studies in vocabulary development, in the summary conditions under which concepts are better developed are given. They are:

> Provision is made for a wide range of experiences, vicarious as well as direct.
>
> Careful instruction in word study should be provided to extend vocabularies and knowledge of word meanings. In this instruction,

> high-level concepts should be related to those at lower levels, and careful differentiation must be made between mere verbalism and established concepts.
>
> The multiple meanings of words provide a means of developing concepts based on vicarious experiences received through language. It must be recognized, however, that high-frequency words are not readily understood, although many of the most frequently used words are multi-meaning in value. (24, p. 285)

Even though the above three suggestions are excellent, they fall short of being a strategy for teachers to follow when directing concept development. What is lacking is a strategy based upon a querying technique which will permit teachers to plug in mentally at that stage of conceptual clarity the student has attained. Stauffer's recent works also fail in being explicit on such a strategy. However, credit and recognition are due Stauffer for his scholarly emphasis in his two recent books on concept development, even though the sections on "Strategies of Concept Attainment" fail to present teaching strategies. What Stauffer offers in strategies is based upon Bruner's work. The following is in the most part Stauffer's section in his book, Teaching Reading As a Thinking Process, on "Strategies of Concept Attainment."

> Studies of concept attainment indicate that the steps involved are successive decisions, with the early decisions clearly affecting the degrees of freedom possible for the later decisions. At the very beginning, . . . he has to make a decision about the nature of the task . . .
>
> A strategy, according to Bruner, et al., is '. . . a pattern of decisions in the acquisition, retention, and utilization of information that serves to meet certain objectives, i.e., to insure certain forms of outcome and to insure against certain others.' (1, p. 54)* A pattern is inferred from the instances a problem-solver seeking to attain a concept decides to test, the inferences he makes, and how he changes these as he meets different contingencies. The ideal for any concept-

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*Note: This and following citations refer to Bruner, et al., A Study of Thinking, New York, 1956.

attainment task is to attain a concept with a minimum number of encounters (rapid solution) and with the least amount of cognitive strain (cognitive economy). Among the objectives of a strategy are the following (1, p. 54)*:

a. To insure that the concept will be attained after the minimum number of encounters with relevant instances.

b. To assure that a concept will be attained with certainty, regardless of the number of instances one must test en route to attainment.

c. To minimize the amount of strain on inference and memory capacity while at the same time insuring that a concept will be attained.

d. To minimize the number of wrong categorizations prior to attaining a concept.

How do people achieve, retain, and transform information necessary for isolating, learning, and using a concept without exceeding their cognitive capacity? Verbal reports of direct experience provide insufficient data to determine how concepts are attained, and accordingly studies have aimed at externalizing observations of the processes of decision-making. This pattern of decision-making is influenced by a number of circumstances: a definition of the task, the nature of the instances encountered, the nature of the validation, the consequences of specific categorizations, and the nature of the imposed restrictions.

It seems apparent that the act of concept or category formation -- the inventive act by which classes are constructed -- can be stripped down to the following (1, pp. 233-234)*:

a. There is an array of instances to be tested, and from this testing is to come the attainment of the concept. The instances can be characterized in terms of their attributes, e.g., color, weight per volume, and in terms of attribute values, the particular color, the particular weight per volume, etc.

b. With each instance, or at least most of them once the task is underway, a person makes a tentative prediction or decision . . . .

c. Any given decision will be found to be correct, incorrect, or varyingly indeterminate. . . .We refer to this as validation of a decision . . . .

d. Each decision-and-test may be regarded as providing potential information by limiting the number of attributes and attribute values that can be considered . . . .

> e. The sequence of decisions made by the person en route to the discovery of more or less valid cues may be regarded as a strategy embodying certain objectives . . .
>
> f. Any decision about the nature of an instance may be regarded as having consequences for the decision-maker . . .
>
> The scientist, the scholar, or any 'learner' for that matter, is faced constantly with 'the task of assimilating information, conserving cognitive strain, and regulating the risk of failure and folly.' This is the behavior of problem-solving or thinking in everyday life. Taking the broader view, Bruner, et al., believe that 'virtually all cognitive activity involves and is dependent on the process of categorizing,' and that the act of categorizing 'derives from man's capacity to infer from sign to significate." (1, p. 246)* Thus it seems that concept development and thinking are virtually synonymous . . . (25, pp. 381-83)

Stauffer's presentation on strategies of concept attainment emphasizes a learning process rather than a teaching process. An examination of the Arnold, Serra, and Stauffer materials reveals a decreasing emphasis on teaching techniques and an increasing explanation of how students learn. Perhaps the past seventy-five years' psychological research in learning problems has resulted in educators slighting the teaching process and giving the learning process more (yet still insufficient) attention than teaching strategies. If students are to benefit from an educator's knowledge of learning processes, the educator must know of and practive teaching strategies which will stimulate learning processes in students. The lack of teaching strategies for directing the development of concepts is greatly hindering educators in applying what psychologists have learned about the process of acquiring a concept.

A survey of three books: The Teaching-Learning Process by James L. Kuethe, (20) Essentials of Learning by Robert Travers, (28) and Exemplars of the Teacher's Cognitive Domain by R. C. Bradley and N. Wesley Earp (2) reveals a continued superficial attention to the teaching of concepts. The Teaching-Learning Process, a Keystones series on education, fails to suggest anything which might be thought of as a strategy for teaching concepts. Essentials of Learning expands upon the subject of concept teaching only a little more. Exemplars of the Teacher's Cognitive Domain contains the following six suggestions about concept teaching in reply to a question, "What is the role of 'concept development' in the reading readiness program?"

> If the pupil is to get meaning from reading, he must first recognize that the words he sees refer to something he knows in life. Hence, experience must be provided which includes excursions, field trips, objects brought to class, viewing of television, sharing times, and the like.
>
> A physical setting in the classroom stimulates concept cevelopment. One corner of the room should be dedicated to the stimulation of interest in reading materials (pictures, books, fish-bowl and chart of instructions for feeding purposes, booklets, and signs). The chalkboard should be filled with plans, directions, and printed information. Bulletin boards should be used for the same purposes.
>
> The ability to describe pictures, tell stories about them, and share ideas with the class will lead in most cases to richer, stronger vocabulary development. This in turn aids the child in good oral expression of one-line and two-line sentences.
>
> Several opportunities must be given for the child to encounter problems dealing with the need for recalling details, comprehending the main idea, and following an orderly sequence of a discussion of experience chart materials.
>
> Concept development is aided when the child strives to select and group ideas, answer questions, and follow written and verbal directions.
>
> The slow learner will need more review of materials since he cannot remember the vocabulary (spoken and written) at a rate suitable for his more normal age-mates. Hence, additional new material and designated time for working with these children must be a significant part of one's planning. (2, p. 190)

When comparing these six suggestions, it can be readily seen that they are all subsumed under Arnold's suggestions made in 1899. Certainly they are not unworthy of teacher consideration; but, they fail to be a strategy a teacher can follow in teaching diagnostically. Concepts are so important that teachers should have a strategy for directing conceptual development which will permit them to diagnose the level of concept attainment, to establish a frame within which to develop a prognosis, and to determine enough direction to teach diagnostically in achieving the goals set in the prognosis.

Vickery showed insight into what a strategy designed for the teaching of concepts might contain when she wrote the following:

> The analytical relations of each concept represented by a word can be determined by asking a series of questions. Is it a member of any class? Is it composed of anything? Is it a component of anything? Is it made up of several members of a class? Does it produce, or is it used for or to anything? Is it made use of, determined or influenced by anything? Is it produced or acted on by, or does it act on anything? Is it characteristically the negative of anything? Has it an important characteristic? Is it like anything which it is not? (30, pp. 45-6)

A survey of the literature reveals a plethora of studies on the mental processes of concept learning and a dearth of creative insight as to what teaching strategies are essential to make use of accumulating knowledge on concept attainment. Therefore, a major problem is the lag between the acquired knowledge of concept attainment and the lack of teaching strategies which would make it possible to apply what is known. The purpose of this study is to explore the possibility that a model developed by J. E. L. Farradane of London may aid in developing a teaching strategy founded upon some of what is known about conceptualization.

Farradane is essentially interested in storage and retrieval of information and work in library-related subjects. It is interesting to note that in discussing present studies on memory and thinking, Bruner suggested considering the organization of a library. Bruner wrote:

> Perhaps in the interest of refreshing our approach we might try to design a memory system, for example, to write some prescriptions for the organization of a library of a specialized kind. How would information about physical chemistry be stored, for example, in order to make it not only more accessible for specific uses but also to free the material in a way that would allow for maximum combination with other information? In what kind of units would it be stored? Would the most frequently used material be put in the most accessible location or would it be reproduced and put in a great many locations? What would the rules of cross-referencing be, and in what order on a list should cross-references be placed? Should there be a metalibrary of the major comprehensive ideas for quick scanning to guide us to more detailed information that we might need? How many such ideas should be included and organized according to what principles? Might such an exercise provide some light on the false leads that lure us in mistaken directions of pursuit? (4, p. 251)

Surely Farradane did ask some, if not most, of these questions from 1950 through 1967, the time span through which he worked on the following model:

→ INCREASING ASSOCIATION →

INCREASING CLARITY OF PERCEPTION ↓

	Cognition	Memory	Evaluation
Recognition	Concurrence	Self-activity	Association
Convergent Thinking	Equivalence	Dimensional (time, space, state)	Appurtenance
Divergent Thinking	Distinctness	Reaction	Functional dependence (Causation)

In this model, Farradane suggests there are nine different stages for which the intellect should develop relationships in the process of attaining conceptual clarity. Since it may give more unity and continuity to this and the other chapters in this report, after each of the nine terms are defined by directly quoting Farradane, the concept of mammal will be used to show how these definitions will control the study while illustrating, hopefully, each definition. Farradane is not responsible for the material used in connection with the concept mammal. Material similar to this will be applied in the explorational study of the model. The answer for each interrogative illustration created by a question is underlined. The terms, their definitions, and interrogative illustrations are as follows.

1. Concurrence -- It implies a mere concurrence or juxtaposition (mentally) of one thing with another. (8, p. 307)

Which picture shows a mammal?

a. Ostrich b. Alligator c. Butterfly d. Man

2. Self-activity -- It describes the intransitive verb situation, such as 'man walking,' 'bird migrating.' (8, p. 307)

Which picture shows something only mammals do?

a. Boy climbing a tree b. Calf nursing

c. Boy swimming d. Deer running

3. Association -- This expresses various forms of association; it may be an unspecified association (e.g., of the Pavlov type), such as prison to disgrace. The relation can also be used to denote the agent of process (e.g., hydrolysis to acid) or the tool of process (e.g., cutting to knife). It is also the link for abstract properties (e.g., cathedral to beauty), or for indirect or calculated properties which are not instrinsic to an object but are imposed by man's thoughts (e.g., sugar to purity, machines to efficiency). (8, p. 307)

Which picture makes you think of mammals?

a. An egg b. Glass of milk c. Larva d. Head of a fish

4. Equivalence -- It expresses sameness either wholly or in some degree. It is the relation between synonyms and can be used

for the introduction of proper names (e.g., Coca Cola = coke). It also expresses the idea of something considered as (or to be used as) something else (e.g., acetone = solvent). (8, pp. 307-08)

Which picture shows two kinds of mammals ?

a. Man and a bird b. Man and a fish

c. Man and a cat d. Man and a snake

5. Dimensional -- Expresses position in space or time, temporary states, and certain temporary properties. Space may concern just relative positions or actual position. Similarly, relative or actual time may be expressed, and the relation of rate or speed (e.g., crystallizing to rate). Temporary states include temperature, electric charge, crystalline form solution, colloidal state, etc. The relation also applies to all states of variable properties or amount or size (e.g., number weight, volume, content, yield, concentration, and such measures as Brix, pH, etc.) (8, p. 308)

Which two animals best show from how small to how large mammals may be ?

a. Whale and small mouse b. Whale and an elephant

c. Elephant and a cow d. Boy and an ape

6. Appurtenance -- Expresses the purely generic relation (e.g., genus to species), the whole-part relation (e.g., pig to liver), or intrinsic ingredient (e.g., molasses to melanoidins). It is also the relation of all physical (intrinsic) properties (e.g., syrup has density, tube has a diameter). (8, p. 308)

Which picture shows something found on mammals ?

a. Scales b. Feathers c. Shells d. Hair

7. Distinctness -- This is rarely required for the mere expression of awareness of difference, but is applicable to the relations of substitutes and imitations. (8, p. 308)

Which picture does not show a mammal ?

a. Bat b. Polar bear c. Ostrich d. Platypus

8. Reaction -- Refers to the action of anything or process on another thing or process (e.g., water on purifying, sugar on acid). (8, p. 308)

Which picture best shows what mammals do to plants?

a. Man spraying a plant

b. Fire burning plants

c. Cow eating grass

d. Man resting under a shade tree

> 9. Functional dependence -- Expresses the relation of A causing B, or B arising out of A, as in the case of a product from a raw material (e.g., bread from wheat), or partly arising out of a primary thing (e.g., book from author, plant from a seed, or a seed from a plant). (8, pp. 308-09)

Which picture best shows what mammals need if there are going to be new or baby mammals?

a. A cow and a horse

b. A cow and a bull

c. Two bulls

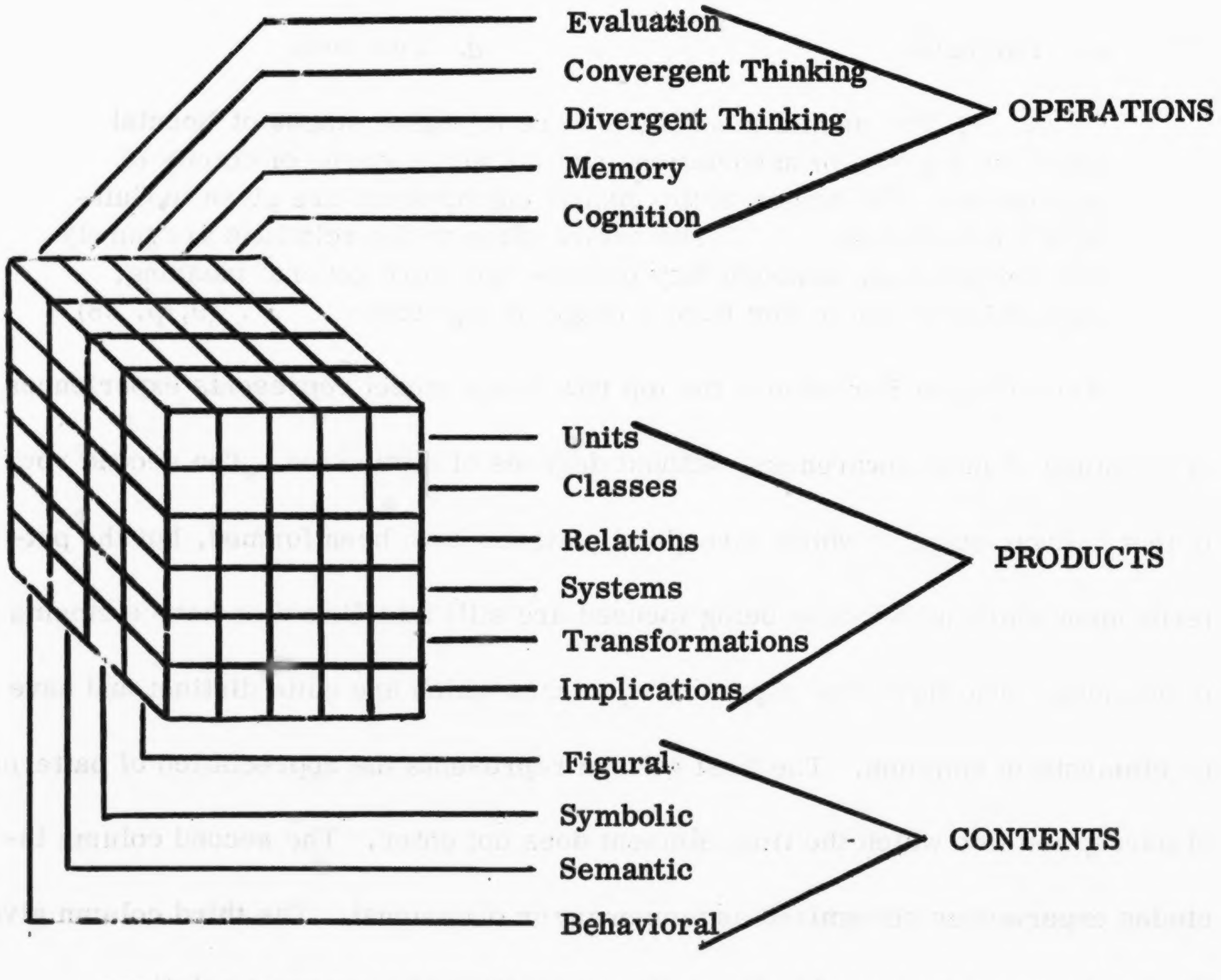
d. Two cows

> . . . The mental mechanisms are (a) three stages of 'mental time' or degrees of association, and (b) three stages of clarity of perception. The stages of the mental mechanisms are given in Guilford's terminology . . . The names given to the relations are purely for convenience; although they indicate the more general meaning, each relation can in fact have a range of application . . . (9, p. 38)

According to Farradane, the top row in his model represents experiences at the stage of mere awareness, without degrees of distinction. The second row is that halfway stage at which perceptual patterns have been formed, but the patterns upon which attention is being focused are still interlinked or have elements in common. The third row represents patterns which are quite distinct and have no elements in common. The first column represents the appreciation of patterns of perception into which the time element does not enter. The second column includes experiences recognized as temporary or occasional. The third column gives the fixed concept in regard to time, the recognition of permanent relations.

Seen in another way, the first column gives the relations of concurrence, non-distinctness, and distinctness by themselves, without the time element; the first row is somewhat analogous in individuality, giving the absence of time and the two appreciations of time, all free from the consideration of distinctness. It should be noted that "time" here is not physical time, but our basic sense of past and present and of repetition or non-repetition of experience. (6, p. 196)

A look at Guilford's "Model Representing the Structure of Intellect" shows the portion Farradane has incorporated into his model.



Evaluation
Convergent Thinking
Divergent Thinking
Memory
Cognition
OPERATIONS
Units
Classes
Relations
Systems
Transformations
Implications
PRODUCTS
Figural
Symbolic
Semantic
Behavioral
CONTENTS

Since only the terms under operations in Guilford's model are incorporated by Farradane, only those terms will be defined.

1. Evaluation -- The act of reaching decisions as to goodness, correctness, suitability, or adequacy of what we know, what we remember, and what we produce in productive thinking.

2. Convergent thinking -- The thinking about information which leads to one right answer or to a recognized best or conventional answer.

3. Divergent thinking -- Thinking operations that go in different directions, sometimes searching, sometimes seeking variety.

4. Memory -- Retention of what is recognized.

5. Cognition -- The act of discovery, re-discovery, or recognition. (12, pp. 267-285)

The term recognition does not appear in Guilford's model. Farradane derived this term by dividing Guilford's term cognition into two operations. Farradane wrote:

> Guilford's definition of cognition should be divided into two operations: simple awareness or conceptualization, which is an early stage in the development of memory, and which can still be called cognition; and the process of identification of one object or concept with another, and hence awareness of two or more objects or concepts together, which may well be called recognition, and has something in common with convergent and divergent production operations. (7, p. 8)

Thus:

6. Recognition -- The process of identification of one object or concept with another, and hence awareness of two or more objects or concepts together. (7, p. 8)

Before more definitive discussion on the objectives and scope of this study is entered into, the definition of concept which will affect the thinking required for the study will be given. A concept is an operational mental unit in a cognitive storage system created when an organism responds emotionally and intellectually to stimuli in the environment which activate the organism mentally through one or more of the senses. The generators of these units are perceptions which stimulate these operational units, causing them to scan past experiences to determine if there are any relations to them and a present experience. If there are relations, the present experience either reaffirms the unit or modifies its information. If there are no relations, a new operational unit in the cognitive system may begin to develop. In reality, an organism can develop concepts to the extent it can relate pertinent past experiences to a present experience.

With this understanding of concept and adhering to terms as defined for the Farradane model, an explorational study will be conducted to determine if the Farradane model offers a basis upon which may be developed a strategy for directing conceptual attainment. The strategy should provide teachers with diagnostic procedures to apply in determining the level of clarity attained for specific concepts, provide a frame within which to develop a prognosis to adhere to in directing development of specific concepts, and give enough direction so teachers may instruct diagnostically until the goals set in the prognosis are achieved.

In exploring the possibilities the Farradane model offers, the statistical technique of factor analysis will be applied in testing the following null hypotheses:

First hypothesis. Responses of subjects in the first, third, or sixth grade to questions on the nine conceptual relations in the Farradane model will not yield through factor analysis nine eigenvalues of 1. (An eigenvalue is a number which represents the critical load for which a factor is responsible in a performance.)

Second hypothesis. Responses of all subjects combined to questions on the nine conceptual relations in the Farradane model will not yield through factor analysis nine eigenvalues of 1.

To further explore the significance of the eigenvalues of 1 and those which may be greater than 1 the information in the correlation coefficient matrices will be applied as criteria against which to evaluate the following null hypotheses:

Third hypothesis. Responses of first, third, or sixth grade subjects to questions on the nine conceptual relations in the Farradane model will not yield for all bivariate comparisons a correlation coefficient significant at the .05 level of statistical confidence.

Fourth hypothesis. Responses of all subjects combined to questions on the nine conceptual relations in the Farradane model will not yield for all bivariate comparisons a correlation coefficient significant at the .05 level of statistical confidence.

If any of the data required for factor analysis suggests subjects' responses to the nine conceptual relations may be scalable, then the following null hypotheses will be tested through scalogram analysis. If this technique is applied, then for fairness to the model and for thoroughness in searching for what sequence of relations will yield the highest coefficient of reproducibility value both the plane and the column sequence of relations found in the Farradane model will be subjected to it. The hypotheses are:

Fifth hypothesis. When analyses of responses of first, third, or sixth grade subjects to questions on the nine conceptual relations are restricted to either the plane or column sequences of relations found in the Farradane model, a unidimensional scale having a coefficient of reproducibility value of .80 or greater will not be verified.

Sixth hypothesis. When analyses of combined responses of all subjects to questions on the nine conceptual relations are restricted either to the plane or column sequences of relations found in the Farradane model, a unidimensional scale having a coefficient of reproducibility value of .80 or greater will not be verified.

In order to test the full implications contained in the model, those relations assigned to the six sub-sets (Recognition, Convergent Thinking, Divergent Thinking, Cognition, Memory, and Evaluation) will be subjected to scalogram analysis to determine if any of the sub-sets are scalable. In determining this, the following null hypotheses will be tested:

Seventh hypothesis. When first, third, or sixth grade subjects responses are analyzed through scalogram analyses based upon the six sub-sets of relations found in the Farradane model, no sub-set of relations will form a unidimensional scale having a coefficient of reproducibility value of .80 or greater.

Eighth hypothesis. When analyses of combined responses of all subjects are examined through scalogram analysis based on the six sub-sets of relations found in the Farradane model, no sub-set of relations will form a unidimensional scale having a coefficient or reproducibility value of .80 or greater.

The following two hypotheses are included for two reasons: (1) to permit an unrestrained manipulation of the conceptual relations in determining if a scalable sequence having a coefficient of reproducibility value of .80 or greater is possible, and (2) what effects chronological age has upon the sequences of relations which yield the highest coefficient of reproducibility value. They are:

Ninth hypothesis. For grade levels or subjects or combined performances, no rearrangement of conceptual relations found in the Farradane model will result in subjects' responses forming a unidimensional scale having a coefficient of reproducibility value of .80 or greater.

Tenth hypothesis. Chronological age will not be a factor in determining which sequence of relations yields the highest coefficient of reproducibility value.

The last hypothesis is included as a criteria against which to determine if the concepts used in the instrument to test the Farradane model were biased toward male or female subjects' attainment of conceptual clarity. In order to determine this, the chi square value as well as coefficient of reproducibility values for the sexes will be derived. The hypothesis is:

Eleventh hypothesis. Sex will not be a factor in determining which sequence of relations yields the highest coefficient of reproducibility value nor will a chi square value be derived which is significant at the .05 level of statistical confidence.

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CHAPTER II

RESEARCH METHODS

The instrument developed for testing the Farradane model will be explained first in the discussion of research methods. The development of the instrument began with the selecting of twenty concepts ranging from first through sixth grade difficulty, according to three series of science texts used in elementary schools. The science series are:

1. Harcourt, Brace and World, Incorporated's Concepts in Science, by Paul F. Brandwein, et al., 1966. (1)

2. Holt, Rinehart and Winston, Incorporated's Science: A Modern Approach, by A. S. Fischler, et al., 1966. (3)

3. Silver Burdett Company's Science, by George G. Mallinson, et al., 1968. (12)

The concepts selected from these three elementary science series are listed below. The number in parentheses to the right of each concept indicates the grade level of the science text from which it was taken.

1. animal (1)
2. earth (1)
3. machine (1)
4. planet (1)
5. plant (1)
6. soil (1)
7. fruit (2)
8. insect (2)
9. seed (2)
10. food (3)
11. mammal (3)
12. reptile (3)
13. tree (3)
14. electricity (4)
15. human (4)
16. skin (4)
17. cell (5)
18. fossil (5)
19. bacteria (6)
20. metal (6)

These twenty concepts were the basis upon which the instrument was developed. Each concept was pictorialized for each of the nine relations suggested in the model. Each relation pictorialized for each concept was done in four different chromatic presentations, three of them being foils. The four chromatic presentations representing each relation were portrayed on an eleven by thirteen and one-helf inch sheet of high quality white art paper divided into four by five inch rectangles. For each concept, there were thirty-six four by five inch rectangular chromatic pictures, or a total of seven hundred twenty pictures in the instrument.

Due to cost, the pictures cannot be reproduced in this report. Photographs of pictures used are with official copies of this dissertation in the University of New Mexico Library. In Appendix A of this report are the questions asked subjects with word descriptions of the pictures. The one underlined is regarded as the most correct answer for that relation.

Since it was essential that subjects understand the questions for each relation, question-phrasing was done with the aid of students from kindergarten through the twelfth grade. The process of developing questions began after the artists had completed the chromatic presentations. Five students, representing grades nine, ten, eleven, and twelve, were asked the initial questions which were used to direct the creation and selection of the seven hundred twenty pictures in the instrument. Each subject was asked to explain why he chose the picture he did as best representing the answer for a particular relation for a specified concept. If the rationale given was based upon the reasoning behind the development of the initial question, it was accepted that the question stimulated the student to mentally search for the answer called for by the relation, even though the student might not have chosen the picture which was designated as being correct. If the student's rationale did not support the reasoning upon which the initial question was based, the question was reworded.

After the joint discussions with the five secondary students, all other students were questioned on an individual basis. All elementary students who were consulted in developing the questions were chosen on the basis of teacher judgment as to whether the student's performance in the classroom was superior, average, or below average. Students from the first, third, and sixth grades receiving teacher judgments of superior, average, and below average performances were chosen, since students coming from these grades would be subjects in the study. One student of average performance was chosen from the second, fourth, and fifth grades respectively.

The questions which stimulated students to mentally search for the picture best representing a particular conceptual relation were asked all subjects in the study, regardless of grade level.

Since the concept of mammal was used in Chapter I to help define and illustrate the relations suggested in the Farradane model, the concept of fossil is used below to show examples of questions in the instrument and word descriptions of the chromatic presentations of pictorial stimuli. The designated answer is underlined.

1. Which picture shows a fossil?

a. A statue of a man	b. Cow skeleton on a desert
c. Human tracks on a beach	d. Standing dinosaur skeleton

2. Which picture shows what fossils have helped man understand?

a. Car
b. House
c. Dinosaur
d. Tree

3. Which picture makes you think of a fossil?

a. An old dead tree standing
b. A small young tree sprouting green leaves
c. A medium sized young tree with green leaves
d. A large tree with green leaves

4. Which picture shows two fossils?

a. Two rocks and a dog with a bone in his mouth
b. A stone with a skeleton impressed in it and 3 arrowheads
c. A stone with imprints of a fern leaf and a trilobite in it
d. A standing dead tree trunk and a petrified dead log near

5. Which pair of circles best shows how small and how large fossils may be?

a. Two circles: smallest - 1/4" in diameter; largest - 1 1/4" in diameter
b. Two circles: both 1/4" in diameter
c. Two circles: both 1 1/4" in diameter
d. Two circles: smallest - 3/4" in diameter; largest - 1 1/4" in diameter

6. Which picture shows what most fossils are like?

a. Three maple leaves
b. A rectangular board
c. Two rocks
d. Block of ice

7. Which picture does not show a fossil?

a. Human tracks on a beach
b. Two leaf-like imprints in a rock
c. A leaf imprint in a rock
d. A shell imprint in a rock

8. Which picture shows what fossils could tell man about?

a. A futuristic-looking machine
b. A cave man in a cave by a fire
c. A modern home
d. An old railroad in a desert

9. Which picture best shows what had to be or exist before fossils were possible?

a. A picture of a cow, rabbit, and plants representing life
b. A rainstorm
c. Clouds, wind, and green grass
c. An active volcano

The instrument described above was administered individually to one hundred three first graders, one hundred nine third graders, and one hundred six sixth graders. These subjects came from the following Las Cruces, New Mexico schools: Alameda, Conlee, Loma Heights, and University Hills. The subjects were randomly selected from a stratified population. To be a member of the stratified population, a subject had to come from a home having the three following characteristics: (1) English as a native or first language for the subject; (2) a northern European cultural heritage; and, (3) an annual disposable family income at or above $6,500. In each of the four schools participating, each student qualified for the study by grade level and the three above characteristics was identified and his or her name placed in a receptacle, from which thirty names for each grade level in each school were drawn. Student qualifications were determined by consulting information cards parents fill out when enrolling a child in the schools, or by asking principals and teachers if the information on the cards was insufficient to make the determination. After the thirty names for each grade in each school had been drawn, the names of those students selected were presented to the principal of each school; his secretary then ran a confirming check to insure that the students were qualified by the established criteria to participate in the study.

The subjects were chosen from grades one, three, and six because there is enough age difference between these grade levels to indicate if chronological age affected subject performance. The language, economic, and cultural restrictions were establish in order to control the following variables: (1) English language proficience; (2) cultural effects; and, (3) educational environment in the home. The $6,500 annual disposable income was derived by referring to The World Almanac 1969. It was found that the per capita income for New Mexico residents in 1967 was $2,477; (15, p. 138) the national disposable income for United States citizens in 1967 was $2,736. (15, p. 315) Since New Mexico's per capita income before taxes and other deductions was lower than the national per capita disposable income, it was estimated that a family of four or more in New Mexico with a disposable income of $6,500 or more would have the financial resources to provide some educational opportunities beside those routinely offered in the home and schools. To realize a disposable income of $6,500 or more, the family provider would have to have a professional or a very technical job.

Concerning the selection of subjects and experimental variables for a study which will apply the statistical technique of factor analysis, Guilford wrote:

> A good factor analysis does give attention to two important sources of determination of the results: the selection of the sample of individuals and the selection of experimental variables. It is important that the sample of individuals . . . be fairly uniform in such characteristics as common culture, age, education, sex, and other demographic variables that may influence the correlation coefficients. Such variables should not be disregarded unless it is shown that they have no appreciable influence on intercorrelations. (6, p. 26)

Since data collected in this study was subjected to factor analysis, Guilford's suggestions were heeded.

Kerlinger defined factor analysis as " . . . a method for determining the number and nature of the underlying variables among large numbers of measures. More succinctly, factor analysis is a method of determining k underlying variables (factors) from n sets of measures, k being less than n. It may also be called a method for extracting common factor variances from sets of measures." (11, p. 650) Fruchter's explanation of the use of factor analysis supports Kerlinger's. Fruchter wrote:

> Factor analysis starts with a set of observations obtained from a given sample by means of such a priori measures. It is a method of analyzing this set of observations from their intercorrelations to determine whether the variations represented can be accounted for adequately by a number of basic categories smaller than that with which the investigation was started. Thus data obtained with a large number of a priori measures may be explained in terms of a smaller number of reference variables. (4, p. 1)

After factor analysis determined the number of factors represented by the model and indicated the significance of the coefficient correlations, subject responses were subjected to scalogram analysis. "In practice, scalogram analysis . . . /is/ a procedure for evaluating sets of statements . . . to determine whether or not they meet the requirements of a particular kind of scale, set forth in some detail by Guttman (1944, 1945, 1947a, 1947b)*." (2, p. 172) Since subject responses were going to be subjected to scalogram analysis, at least one hundred subjects per grade level were required. Guttman stated, "In the pre-test for a survey, about 100 persons will usually constitute an adequate sample of the population to test the hypothesis of scalability." (10, p. 249)

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*Note: 1944 is reference number 7, 1945 is reference number 8, 1947a is reference number 9, and 1947b is reference number 10, given at the end of this chapter.

Since scalogram analysis is based on an analysis of the response patterns of subjects to items, where a response pattern denoted the set of responses to items given by a subject (13, p. 307), a method of scalogram analysis had to be chosen. The method selected was developed by Goodenough in 1944. (5, pp. 179-190) Edwards gave this technique the following evaluation: "This method . . . enables us to determine the coefficient of reproducibility in such a way that the coefficient does accurately represent the degree of accuracy with which we can reproduce the responses to statements from total scores alone." (2, p. 184)

Before this method is explained in more detail and terms defined, an illustrative worksheet for scalogram analysis based upon the nine relations in the Farradane model will be explained. This will make it possible to demonstrate how the data collected in this study were manipulated in order to apply scalogram analysis. Figure 1 on the following page contains an illustrative worksheet for scalogram analysis. The word "Relations" on the top horizontal line in figure 1 refers to the nine conceptual relations found in the Farradane model. These nine relations are given in the first set of vertical spaces at the top of the figure. The sequence of these relations in figure 1 is the same as the plane sequence found in the Farradane model. The first three relations Concurrence, Self-activity, and Association, form the plane of Recognition or first plane. The second set of three relations, Equivalence, Dimensional, and Appurtenance, form

Figure 1

ILLUSTRATIVE WORKSHEET FOR SCALOGRAM ANALYSIS

	Relations or Statements																			
	Concurrence		Self-activity		Association		Equivalence		Dimensional		Appurtenance		Distinctness		Reaction		Functional dependence		scores	errors
	20		20		20		20		20		20		20		20		20			
	Criteria for dichotomizing subjects' responses: First grade - credit: 12-20 correct responses - no credit: 0-11 correct responses Third and sixth grade - credit: 15-20 correct responses - no credit: 0-14 correct responses																			
	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O		
6 - 1*	X		X		X		X		X		X		X		X		X		9	0
6 - 2	X		X		X		X			O	X		X		X		X		8	4
3 - 3*	X		X		X			O	X		X		X		X			O	7	4
6 - 4	X		X		X		X		X		X		X			O		O	7	0
1 - 5	X		X		X			O		O	X		X			O	X		6	3
3 - 6*	X		X		X			O	X			O	X			O		O	5	2
6 - 7	X			O		O		O	X			O	X		X			O	4	3
1 - 8*	X			O		O		O		O	X			O	X			O	3	2
3 - 9	X			O		O		O		O	X			O		O		O	2	1
1 - 10*	X			O		O		O		O		O		O		O		O	1	0
frqnc.	10	0	6	4	6	4	3	7	5	5	7	3	7	3	5	5	3	7	54	18
p	.10		.6		.6		.3		.5		.7		.7		.5		.3		.6	
q	.0		.4		.4		.7		.5		.3		.3		.5		.7		.4	

the second plane or the plane of Convergent Thinking. The last set of three relations, Dimensional, Reaction, and Functional dependence, form the third plane or the plane of Divergent Thinking. This order was selected just because it is in the model.

The numeral 20 under each of the relations refers to the number of times each subject responded to questions pertaining to that relation. The number of times (20) students responded to questions pertaining to various relations is pertinent to the criteria for dichotomizing subjects' responses for the purposes of scalogram analysis. That is, how many time does a subject have to respond correctly to a relation in twenty chances to be given credit. A discussion of how this decision was made should help one understand the information contained in the large rectangular in figure 1.

A report by Wohwill on a conceptual study analyzed in part by scalogram analysis (which applied the criteria of five correct out of six items, and ten correct out of twelve items to receive credit) directed this study's search for cutting points to give a meaningful dichotomization of subjects' responses. (14, p. 374) The criteria for dichotomizing first grade subjects' responses differ from those of the third and sixth grade subjects for the following reasons: (1) assigning credit to relations for first grade subjects on the basis of making fifteen to twenty correct responses out of twenty choices would result in approximately thirteen per cent of their responses receiving credit; and (2) the fifteen to twenty correct criterion for credit for first grade subjects yields an unacceptable skewness in scores. For instance, thirty-four of the one hundred three-first grade subjects under this criterion would have received scores of zero; another thirty-eight would have received scores of one.

If first grade subjects' performances were going to be meaningful for the study, they would have to be judged by different credit/no credit criteria. The twelve to twenty correct responses for credit, and zero to eleven correct responses for no credit, proved to be criteria which would permit first grade subjects' performances to contribute to the study. Under this criteria, forty-four per cent of their responses received credit.

Enough responses of third and sixth grade subjects received credit to warrant holding subjects from both of these grade levels to the fifteen to twenty correct responses for credit, and from zero to fourteen correct responses for no credit criteria. Under these criteria, forty-six per cent of third grade subjects' responses received credit and seventy-four per cent of sixth grade subjects' responses received credit. Thus, the criteria for the first grade subjects and those for the third and sixth grade subjects permit enough chance for no credit to occur that it is possible to determine if certain relations identified in the Farradane model receive credit from subjects' responses when other relations do not. That is, there is enough margin for credit and for no credit that it is possible for a hierarchal pattern of responses to the nine relations to emerge is there is one.

The above discussion gives the rationale for the information contained in the large rectangle in figure 1. The small boxes with the X,O,X,O, X,O series in them designate the credit/nocredit columns for each of the nine conceptual relations. That is, if a subject gets enough responses correct for credit, he receives an "X" in the X or credit column. If he does not get enough responses correct for credit, he receives a "O" in the O or no credit column.

A look at the first subject and his scores will illustrate how a subject receives credit. The subject's code is 6 - 1*. This code contains three bits of information about the subject. The first numeral _6_ indicates that the subject is in the sixth grade. The second numeral _1_ indicates that the subject has rank one because he has the highest score. The asterisk reveals that this subject is a male student. Those codes without an asterisk represent female subjects.

As can be seen the first subject received credit for all of his responses to the nine different conceptual relations. Therefore, he has a score of 9 and has no errors. However, the second subject (6 - 2) is a female sixth grader with a score of eight and has four errors. Notice that she received credit for the first four relations (Concurrence, Self-activity, Association, and Equivalence) but failed to receive credit for the relation of Dimensional which results in her receiving a "O" in the no credit column. After receiving the no credit for the relation of Dimensional, she received credit for the following four relations (Appurtenance, Distinctness, Reaction, and Functional dependence). In scalogram analysis after a subject received no credit for an item in a sequence, any credit or credits he received for items after the item for which he received no credit are counted as errors. Therefore, subject 2 has a score of eight with four errors.

The frequency row just beneath the score rows for subjects contains the number of times the various conceptual relations received credit and no credit.

For instance, the conceptual relation of Concurrence was awarded credit ten times from ten students. Self-activity has credit six times and no credit four times. The last two positions in the frequency row contain the total score and the total number of errors.

The p and q rows at the bottom of the illustrative worksheet shows proportions for credit and no credit. p represents credit; q represents no credit. the proportions giving the no credit response will be $1 - p = q$.

It is essential to know the number of errors if the coefficient of reproducibility is to be derived. The coefficient of reproducibility value indicates the per cent of accuracy with which responses to the various statements (relations) can be reproduced from the total scores. (2, p. 183) Coefficient of reproducibility (CR) is defined by the following formula:

$$CR = 1 - \frac{\text{total number of errors}}{\text{total number of responses}}$$

Since each subject responds once to each item, it is apparent that:

$$CR = 1 - \frac{\text{total number of errors}}{\text{number of items} \times \text{number of subjects}} \quad (13, p. 313)$$

Using the information in the illustration, the coefficient of reproducibility is:

$$CR = 1 - \frac{18}{9 \times 10} = 1 - \frac{18}{90} = 1 - .20 = .80$$

$$CR = .80$$

A coefficient of reproducibility of .80 is not high enough to indicate absolute scalability. Torgerson explained, "Reproducibility is the primary criterion of scalability. Originally a [coefficient of] reproducibility of 0.85 was arbitrarily selected as the dividing line separating scales from non-scales. More recently, a [coefficient of] reproducibility of 0.90 or better has been taken as the standard." (13, p. 323) However, since this is an exploratory study, a coefficient of reproducibility of 0.80 would warrant further interest. Also, because of the experimental type instrument used in the study, a coefficient of reproducibility of 0.80 would support further interest in studying the Farradane model for discovering ideas to apply in developing a strategy to teach concepts.

In searching for a maximum coefficient of reproducibility, the order of the relations in the Farradane model was shifted. For example, in the illustration, the relation distinctness has a frequency of seven credits to three no credits. To minimize error, the relation could be shifted to come right after concurrence, which would increase the coefficient of reproducibility. Shifting the relation appurtenance left to the third position would increase the coefficient of reproducibility and minimize error. The relations in the Farradane model were reordered in search for a sequence upon which a strategy for teaching concepts may be based. The reordering of the sequence was determined by the frequency of credit given to each relation, with the relation receiving the highest frequency getting rank one, and the relation with the lowest frequency getting rank nine.

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CHAPTER III

DATA AND RATIONALES

The hypotheses and the data's affects upon them are presented in the sequential order in which the hypotheses were stated at the end of Chapter I. Only a statistical presentation with essential interpretative comments appear in the first section of Chapter III. A discussion of the portents the data hold for the study is given in the second section of this chapter.

Data and the Hypotheses

Factor Analysis: Hypotheses one and two

First hypothesis. Responses of subjects in the first, third, or sixth grade to questions on the nine conceptual relations in the Farradane model will not yield through factor analysis nine eigenvalues of 1.

First grade subjects

Performances of first grade subjects yielded through factor analysis one eigenvalue greater than 1. As can be seen on Data Table 1, this eigenvalue was 3.7841 and represented 42.6451 per cent of trace or that which accounted for subjucts' performance on the instrument used in testing the Farradane model. The model suggests nine factors; and theoretically each factor would represent approximately 11.11 per cent of trace or that which accounts for performance. However, only one factor was derived which represented as much or more of the per cent of trace theoretically allotted to each of the nine suggested factors. The one derived accounted for almost enough of the per cent of trace allotted to four of

DATA TABLE 1

LOADINGS FOR EIGENVALUES GREATER THAN 1

Grade	First	Third		Sixth	Combined
Number	103	109		106	318
Factors	One	One	Two	One	One
Concurrence	-.5996	.1901	.8079	-.7127	-.7724
Self-activity	-.7025	-.6400	.3366	-.7521	-.8707
Association	-.5821	-.5744	.1883	-.6563	-.7742
Equivalence	-.6386	-.3911	.6683	-.7967	-.8512
Dimensional	-.6244	-.3938	.6155	-.6283	-.8286
Appurtenance	-.7275	-.5035	.3532	-.5450	-.8220
Distinctness	-.6540	-.2976	.5325	-.6656	-.7710
Reaction	-.6210	-.6554	.2770	-.6431	-.8304
Functional dependence	-.6721	-.7916	-.1696	-.7834	-.6424
EIGENVALUES GREATER THAN 1					
	3.7841	3.3842	1.2412	4.1000	5.9388
PER CENT OF TRACE FOR EIGENVALUES GREATER THAN 1					
	42.0451	37.6017	13.7813	45.5551	65.9876

the theoretical factors. Therefore, there was enough left over and distributed among eight other theoretical factors which accounts for whatever else was responsible for subject performance on the instrument. However, no single one of these theoretical eight was significant enough in affecting performance to attain an eigenvalue of 1. Because of the above presentation, the first hypothesis was accepted for first grade subjects.

As shown in Data Table 1, the one eigenvalue derived which was as great or greater than 1 has relatively high loadings on each of the nine proposed factors. Since each loading has a minus in front of it, their significance was as important as if they were all positive. That is, they are all in approximately the same position from an orthogonal perspective.

Third grade subjects

Unlike first grade subjects, third grade subjects' performances yielded two eigenvalues as great or greater than one. They were 3.3842 and 1.2412 as found on Data Table 1. The larger eigenvalue accounted for 37.6017 per cent of trace and the smaller for 13.7813 or a 51.3930 cumulative per cent of trace. Thus, these two factors accounted for about one half of what affected third grade subjects' performances leaving a residue distributed among the other seven theoretical factors which accounted for whatever else affected their performance.

In factor loadings, the smaller eigenvalue loads relatively high on four of the nine conceptual relations suggested in the Farradane model. They are: Concurrence, Equivalence, Dimensional, and Distinctness. Three of these, Concurrence, Equivalence, and Distinctness, are in the mental operational column of Cognition found in the Farradane model. All four loadings which were relatively high for the smaller eigenvalue were positive. Those which load high for the larger eigenvalue were negative. In fact, all the loadings were negative for the larger eigenvalue; but, the high loadings appear to have a range unique to themselves.

The first hypothesis was accepted for third grade subjects.

Sixth grade subjects

Sixth grade subjects performances as evaluated through factor analysis were in agreement with first grade subjects basically. For sixth grade subjects, there was only one eigenvalue as great or greater than 1. It was 4.1000 which represents 45.5551 per cent of trace. Just as sixth grade subjects' performance yielded a larger eigenvalue so were the factor loadings larger. A comparison also showed that what had the lowest loading for sixth grade subjects had the highest for first grade subjects. It is the relation of appurtenance. Thus, while agreeing in eigenvalues, they fail to agree in loadings. The first hypothesis was accepted for sixth grade subjects.

Second hypothesis. Responses of all subjects combined to questions on the nine conceptual relations in the Farradane model will not yield through factor analysis nine eigenvalues of 1.

As can be seen in Data Table 1, combined subject performances resulted in a more dominating single eigenvalue which had high loadings. The eigenvalue was 5.9388 and represents 65.9876 per cent of trace which accounted for what affected subjects' performances. The factor loadings had a range of -.6424 to -.8707. Thus, cross grade analysis yielded an eigenvalue so dominant that it eliminated the two factor influence found affecting third grade subjects' performances. Upon these results was based the acceptance of the second hypothesis.

Correlation Coefficient Matrices: Hypotheses Three and Four

Third hypothesis. Responses of first, third, or sixth grade subjects to questions on the nine conceptual relations in the Farradane model will not yield for all bivariate comparisons a correlation coefficient significant at the .05 level of statistical confidence.

First grade subjects

An examination of the r's in Data Table 2a will show that the third hypothesis had to be rejected for first grade subjects. All the r's were greater than the .195 required for the .05 level of confidence for at least one hundred subjects. In fact, thirty-two r's were high enough to meet the .245 requirement for the .01 level of confidence.

Third grade subjects

Unlike first grade subjects, third grade subjects' performances required that the third hypothesis be accepted. In Data Table 2b, there were seven r's which were not significant at the .05 level of confidence. However, twenty-nine r's were significant with twenty-six of them being significant at the .01 level of statistical confidence.

Six of the seven r's which were not significant at the .05 level are associated with the two conceptual relations of Concurrence and Distinctness. Four of these are correlated with Concurrence and two with Distinctness. Both of these conceptual relations have rather high loadings for the third grade subject eigenvalue of 1.2412. Of course, this helps to explain why third grade subjects' performances yielded two eigenvalues as great or greater than 1.

Sixth grade subjects

Matrices of Correlation Coefficients for Grades One (2a) and Three (2b)

DATA TABLE 2a

	X 1	X 2	X 3	X 4	X 5	X 6	X 7	X 8	X 9
X 1	1.00								
X 2	.346*	1.00							
X 3	.370*	.227	1.00						
X 4	.409*	.391*	.309*	1.00					
X 5	.247	.434*	.226	.282*	1.00				
X 6	.299*	.408*	.409*	.433*	.384*	1.00			
X 7	.328*	.455*	.339*	.290*	.294*	.417*	1.00		
X 8	.206	.338*	.300*	.313*	.411*	.395*	.305*	1.00	
X 9	.346*	.430*	.287*	.297*	.365*	.424*	.362*	.369*	1.00

* significant at .01 level of confidence

DATA TABLE 2b

	X 1	X 2	X 3	X 4	X 5	X 6	X 7	X 8	X 9
X 1	1.00								
X 2	.160+	1.00							
X 3	.150+	.310*	1.00						
X 4	.353*	.423*	.327*	1.00					
X 5	.264*	.403*	.260*	.469*	1.00				
X 6	.175+	.285*	.311*	.417*	.369*	1.00			
X 7	.256*	.316*	.165+	.361*	.368*	.153+	1.00		
X 8	.889*	.477*	.275*	.342*	.396*	.346*	.343*	1.00	
X 9	-.102+	.354*	.332*	.212	.174+	.264*	.213	.316*	1.00

+ not significant at .05 level of confidence

* significant at .01 level of confidence

As shown in Data Table 2c, with the exception of one r, sixth grade subjects' performances yielded correlations with were significant of the .01 level of confidence. Upon this evidence the third hypothesis was rejected for sixth grade students. Again, sixth grade students were in agreement with first grade subjects basically with third grade subjects' performances forming an anomaly.

Fourth hypothesis. Responses of all subjects combined to questions on the nine conceptual relations in the Farradane model will not yield for all bivariate comparisons a correlation coefficient significant at the .05 level of statistical confidence.

The fourth hypothesis had to be rejected without reservation based upon the information in Data Table 2d. All the r's were far larger than the .113 required for hundred subjects at the .05 level of confidence. In fact, even the smallest r in this correlation coefficient matrix far exceeds the .149 requirement for the .01 level of confidence. The range of r's in this matrix was from .503 to .710. Data Table 2d appears to have r's far larger than the r's in Data Tables 2a, 2b, and 2c would lead one to expect to occur when r's were derived for performances across grade levels. In fact, as the population of subjects increased so did the sizes of the r's.

Scalogram Analysis: Hypotheses Five through Ten

Fifth hypothesis. When analyses of responses of first, third, or sixth grade subjects to questions on the nine conceptual relations are restricted to either the plane or column sequences found in the Farradane model, a unidimensional scale having a coefficient of reproducibility value of .80 or greater will not be verified.

Matrices of Correlation Coefficients for Grade Six (2c) and Combined Grade Levels (2d)

DATA TABLE 2c

	X 1	X 2	X 3	X 4	X 5	X 6	X 7	X 8	X 9
X 1	1.00								
X 2	.429*	1.00							
X 3	.337*	.472*	1.00						
X 4	.508*	.548*	.591*	1.00					
X 5	.385*	.385*	.298*	.376*	1.00				
X 6	.294*	.377*	.291*	.375*	.282*	1.00			
X 7	.557*	.384*	.304*	.436*	.372*	.256*	1.00		
X 8	.439*	.439*	.267*	.405*	.409*	.249*	.398*	1.00	
X 9	.315*	.455*	.383*	.488*	.346*	.306*	.309*	.299*	1.00

* significant at .01 level of confidence

DATA TABLE 2d

	X 1	X 2	X 3	X 4	X 5	X 6	X 7	X 8	X 9
X 1	1.00								
X 2	.619*	1.00							
X 3	.552*	.620*	1.00						
X 4	.661*	.710*	.645*	1.00					
X 5	.595*	.703*	.564*	.653*	1.00				
X 6	.574*	.669*	.604*	.672*	.653*	1.00			
X 7	.591*	.636*	.519*	.598*	.592*	.567*	1.00		
X 8	.564*	.707*	.582*	.650*	.686*	.646*	.600*	1.00	
X 9	.503*	.669*	.586*	.611*	.590*	.608*	.547*	.615*	1.00

* significant at .01 level of confidence

The Plane Sequence

First grade subjects

On the following page is Data Table 3a. This table contains the information upon which the fifth hypothesis was accepted for first grade subjects. The information in Data Table 3a can be derived by going to the scalogram analysis charts in appendix B and manipulating the scores there in for each grade level of subjects. As can be seen on Data Table 3a, the three sets of conceptual relations in their sequential order are given which comprise the three planes in the Farradane model. Under each relation the frequency of credit and no credit is given with the proportions for credit and no credit also available. The total number of scores is in the table. The most essential figures for computing the coefficient of reproducibility are provided in the total number of errors and the total number of responses columns.

The total number of responses is obtained by multiplying the number of subjects by the number of relations or statements. Since there are 103 first grade subjects and nine relations or statements, the total number of responses equals 9 X 103 or 927 responses. The coefficient of reproducibility is computed right in the table and was .72. Since the .72 was smaller than the .80 established in the fifth hypothesis, this hypothesis was accepted for first grade subjects.

Third grade subjects

A check with the information for third grade subjects in Data Table 3a which is related to the plane sequence of relations in the Farradane model also indicates why the section of the fifth hypothesis associated with the plane sequence was accepted for third grade subjects. A coefficient of reproducibility value of .75 was smaller than .80 established as a criterion on which to base rejection or acceptance

DATA TABLE 3a

Synopses of Subjects' Performances by Grade Level on the Plane Sequence of Conceptual Relations

Relations or Statements

Number of subjects per grade	Recognition 1st plane						Convergent Thinking 2nd plane						Divergent Thinking 3rd plane						Total number of scores	Total number of errors	Total number of responses
	Concurrence		Self-activity		Association		Equivalence		Dimensional		Appurtenance		Distinctness		Reaction		Functional dependence				
	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O			
103	First Grade Subjects																				
	$\text{CR}^* = 1 - \frac{263}{927} = 1 - .28 = .72$																		CR = .72		
frqn.	91	12	30	73	29	74	39	64	35	68	57	46	84	19	25	78	16	87	404	263	927
p	.88		.29		.28		.38		.34		.55		.82		.24		.16				
q	.12		.71		.72		.62		.66		.45		.18		.76		.84				
109	Third Grade Subjects																				
	$\text{CR} = 1 - \frac{243}{981} = 1 - .25 = .75$																		CR = .75		
frqn.	87	22	38	71	29	80	25	84	47	62	50	59	74	35	27	82	14	95	392	243	981
p	.80		.35		.27		.22		.43		.46		.68		.25		.13				
q	.20		.65		.73		.78		.57		.54		.32		.75		.87				
106	Sixth Grade Subjects																				
	$\text{CR} = 1 - \frac{304}{954} = 1 - .30 = .70$																		CR = .70		
frqn.	104	2	78	28	57	49	67	39	88	18	92	14	94	12	73	33	48	58	703	304	954
p	.98		.74		.54		.62		.83		.87		.86		.69		.45				
q	.02		.26		.46		.38		.17		.13		.14		.31		.55				

*CR represents "coefficient of reproducibility."

of the fifth hypothesis.

Sixth grade subjects

Sixth grade subjects like first and third grade subjects had a coefficient of reproducibility value based on their performances being analyzed through scalogram analysis which required accepting the fifth hypothesis related to the plane sequence. The total number of errors (303) divided by the total number of responses (954) subtracted from 1 yielded a coefficient of reproducibility value of .70 which was smaller than .80. As can be seen in Data Table 3a, all three grade level of subjects were fairly close in coefficient of reproducibility values. For first grade subjects it was .72; third grade subjects .75; and sixth grade subjects .70.

The Column Sequence

First grade subjects

Data Table 3b on the following page is similar to Data Table 3a. The only difference being that Data Table 3b contains information related to the column sequence of conceptual relations found in the Farradane model. The column sequence of relations differ from the plane sequence but the frequencies of credit and no credit are the same. So are the proportions of credit and no credit. They are just in different positions. Being in different positions causes a change in the total number of errors which increases or decreases the coefficient of reproducibility value. Thus, first grade subjects for the column sequence of conceptual relations had a total number of errors of 216 which was less than the 263 for the plane sequence. With this number of errors, a coefficient of reproducibility value of .77 is realized. The .77 was not quite large enough to require rejecting for first grade subjects that portion of the fifth hypothesis associated with the column sequence. Therefore, it was accepted.

DATA TABLE 3b

Synopses of Subjects' Performances by Grade Level on the Column Sequence of Conceptual Relations

Relations or Statements

Number of subjects per grade	Cognition						Memory						Evaluation						Total number of scores	Total number of errors	Total number of responses
	1st column						2nd column						3rd column								
	Concurrence		Equivalence		Distinctness		Self-activity		Dimensional		Reaction		Association		Appurtenance		Functional dependence				
	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O			
103	**First Grade Subjects**																				
	$\mathrm{CR}^* = 1 - \frac{216}{927} = 1 - .23 = .77$																		CR = .77		
frqn.	91	12	39	64	84	19	30	73	35	68	25	78	29	74	57	46	16	87	404	216	927
p	.88		.38		.82		.29		.34		.24		.28		.55		.16				
q	.12		.62		.18		.71		.66		.76		.72		.45		.84				
109	**Third Grade Subjects**																				
	$\mathrm{CR} = 1 - \frac{247}{981} = 1 - .25 = .75$																		CR = .75		
frqn.	87	22	25	84	74	35	38	71	47	62	27	82	29	80	50	59	14	95	392	247	981
p	.80		.22		.68		.35		.43		.25		.27		.46		.13				
q	.20		.78		.32		.65		.57		.75		.73		.54		.87				
106	**Sixth Grade Subjects**																				
	$\mathrm{CR} = 1 - \frac{249}{954} = 1 - .26 = .74$																		CR = .74		
frqn.	104	2	67	39	94	12	78	28	88	18	73	33	57	49	92	14	48	58	703	249	954
p	.98		.62		.86		.74		.83		.69		.54		.87		.45				
q	.02		.38		.14		.26		.17		.31		.46		.13		.55				

*CR represents "coefficient of reproducibility."

Third grade subjects

In Data Table 3b, a coefficient of reproducibility value of .75 has been computed for third grade subjects' performance on the column sequence of conceptual relations in the Farradane model. Therefore, this portion of the fifth hypothesis was accepted for third grade subjects. There was not enough difference in error accumulation for third grade subjects between performance on the plane sequence and column sequence to affect a change in the coefficient of reproducibility value.

Sixth grade subjects

As can be seen in Data Table 3b a coefficient of reproducibility value of .74 required the column sequence portion of the fifth hypothesis be accepted for sixth grade subjects. As in the plane sequence of reproducibility values, each grade level of subjects had a coefficient of reproducibility value for the column sequence which was not much larger than the other groups. Only .03 in the coefficient of reproducibility values for the column sequence separate the highest from the lowest.

Sixth hypothesis. When analyses of combined responses of all subjects to questions on the nine conceptual relations are restricted either to the plane or column sequences of relations found in the Farradane model, a unidimensional scale having a coefficient of reproducibility value of .80 or greater will not be verified.

The Plane Sequence

Since the fifth hypothesis was accepted for each grade level of subjects, it logically follows that the sixth hypothesis was accepted. To demonstrate this, one could refer to Data Table 3a and total the errors of all three groups of subjects and divide the sum of errors by the total number of responses. Thus for the plane sequence:

$$CR = 1 - \frac{263 + 243 + 304}{9(103 + 109 + 106)} = 1 - \frac{810}{2862} = 1 - .28 = .72$$

Since .72 was less than the established .80 in the sixth hypothesis, the hypothesis was accepted.

The Column Sequence

Data Table 3b contains the figures which, if manipulated correctly, will give the coefficient of reproducibility value for the column sequence of the conceptual relations found in the Farradane model. They are and the manipulation are as follows:

$$CR = 1 - \frac{216 + 247 + 249}{9(103 + 109 + 106)} = 1 - \frac{712}{2862} = 1 - .25 = .75$$

That portion of the sixth hypothesis associated with the column sequence was accepted for combined subject performance.

Seventh hypothesis. When first, third, or sixth grade subjects responses are analyzed through scalogram analyses based on the six sub-sets of relations found in the Farradane model, no sub-set of relations will form a unidimensional scale having a coefficient of reproducibility value of .80 or greater.

First grade subjects

Data Table 4 on the following page contains the necessary figures to derive the coefficient of reproducibility values essential in determining whether to accept or reject the seventh hypothesis. The mental operational appellations given each sub-set of conceptual relations by Farradane is listed. Under each sub-set name are the numbers of scores, errors, and responses. Also the coefficient of reproducibility value is given for each sub-set.

To derive first grade subjects' coefficient of reproducibility value for the sub-set of Recognition, one would use the total number of errors figure (23) and

DATA TABLE 4

Synopses of Scalogram Analysis for Grade Levels on the Six Mental Operational Sub-sets

	Sub-sets of Relations					
	Recognition	Convergent Thinking	Divergent Thinking	Cognition	Memory	Evaluation
First Grade Subjects						
Total number of scores	152	126	122	217	91	100
Total number of errors	23	59	12	56	36	44
Total number of responses	309	309	309	309	309	309
Coefficient of reproducibility	.93*	.81*	.96*	.82*	.88*	.86*
Third Grade Subjects						
Total number of scores	153	122	111	193	117	92
Total number of errors	27	64	10	58	36	38
Total number of responses	327	327	327	327	327	327
Coefficient of reproducibility	.92*	.80*	.97*	.82*	.89*	.88*
Sixth Grade Subjects						
Total number of scores	238	247	208	262	241	198
Total number of errors	7	69	16	34	42	61
Total number of responses	318	318	318	318	318	318
Coefficient of reproducibility	.98*	.78+	.95*	.89*	.87*	.81*

*Requires rejection of the hypothesis. +Requires acceptance of the hypothesis.

the total number of responses figure (309). Thus:

$$CR = 1 - \frac{23}{309} = 1 - .07 = .93 \qquad CR = .93$$

As indicated in the first grade subjects' section of Data Table 4 in the coefficient of reproducibility row, all the coefficient of reproducibility values for the six sub-sets of conceptual relations required that the seventh hypothesis be rejected. The values were: Recognition .93; Convergent Thinking .81; Divergent Thinking .96; Cognition .82; Memory .88; and Evaluation .86. All of these values were greater than the .80 set for rejecting the hypothesis.

Third grade subjects

The third grade section of Data Table 4 is just like that for first grade subjects. There is a total of 327 responses for each sub-set of conceptual relations in the third grade section because each sub-set has three relations or statements and there are 109 third grade subjects. Thus, 3 X 109 equals 327. Each coefficient of reproducibility value for the six different sub-sets was greater than the .80 set in the seventh hypothesis. Therefore, for third grade subjects the seventh hypothesis was rejected.

Sixth grade subjects

As shown in Data Table 4 there is one sub-set of conceptual relations which was not large enough to support rejecting completely the seventh hypothesis for sixth grade subjects. The sub-set of Convergent Thinking has a coefficient of reproducibility value of .78 which was smaller than the .80 set in the hypothesis as a bases for rejection. Therefore, for this particular sub-set the seventh hypothesis was accepted for the sixth grade subjects. However, the other five sub-sets have coefficient of reproducibility values large enough to warrant rejection of the seventh hypothesis. They were: Recognition .98; Divergent Thinking .95; Cognition .89; Memory .87; Evaluation .81.

Eighth hypothesis. When analyses of combined responses of all subjects are examined through scalogram analysis based on the six sub-sets of relations found in the Farradane model, no sub-set of relations will form a unidimensional scale having a coefficient of reproducibility value of .80 or greater.

The rejection of the eighth hypothesis was based upon the information in Data Table 5.

DATA TABLE 5

Synopsis of Scalogram Analysis for Combined Subjects on the Six Mental Operational Sub-Sets

	Sub-Sets of Relations					
	Recognition	Convergent Thinking	Divergent Thinking	Cognition	Memory	Evaluation
Total number of scores	543	495	441	672	449	390
Total number of errors	54	192	38	148	114	143
Total number of responses	954	954	954	954	954	954
Coefficient of reproducibility	.94*	.80*	.96*	.84*	.88*	.85*

*Requires rejection of the hypothesis.

The sub-sets of Recognition and Divergent Thinking have coefficient of reproducibility values so high (.94 and .96) because their sequence in the model begins with one of the conceptual relations which subjects' performances indicated to be less difficult. The Divergent Thinking sub-set of relations begins with the relation distinctness, goes next to reaction and concludes with functional dependence. Subject performances indicated the relation of Distinctness was easier than that of Reaction, and that Reaction was easier than Functional Dependence. Therefore, the high coefficient of reproducibility value of .96 should be expected. The Recognition sub-set of relations have the order of easiest to most difficult, which explains the high coefficient of reproducibility value of .94.

The Convergent Thinking sub-set of conceptual relations attained a coefficient of reproducibility value of .80 which is right on the mark for rejection. The conceptual relations of appurtenance comes at the end of this sub-set; yet, by standards of subjects' performances, it is the easiest in the sub-set. Therefore, all the sub-sets in the Farradane model do not have orders of conceptual relations from easiest to most difficult.

Ninth hypothesis. For grade levels of subjects or combined performances, no rearrangement of conceptual relations found in the Farradane model will result in subjects' responses forming a unidimensional scale having a coefficient of reproducibility value of .80 or greater.

First grade subjects

Data Table 6 contains both the sequence of conceptual relations which yielded the highest coefficient of reproducibility value and the figures essential for deriving that value. For first grade subjects the figures are 136 errors and 927 responses. Data Table 6 is on the following page. As can be seen the coefficient of reproducibility value for first grade subjects was .85 which is larger than the .80 set in the ninth hypothesis. Therefore, this hypothesis was rejected for first grade subjects.

DATA TABLE 6

Sequential Positions of Conceptual Relations for Grade Levels and Combined Performances Yielding the Highest Coefficient of Reproducibility Values

Positions	First Grade	Third Grade	Sixth Grade	Combined
1	Concurrence →	Concurrence →	Concurrence →	Concurrence
2	Distinctness →	Distinctness →	Distinctness →	Distinctness
3	Appurtenance →	Appurtenance →	Appurtenance →	Appurtenance
4	Equivalence	Dimensional →	Dimensional →	Dimensional
5	Dimensional	Self-activity →	Self-activity →	Self-activity
6	Self-activity	Association	Reaction	Equivalence
7	Association	Reaction	Equivalence	Reaction
8	Reaction	Equivalence	Association →	Association
9	Functional dependence →	Functional dependence →	Functional dependence →	Functional dependence
Scores	404	392	703	1499
Errors	136	159	168	477
Responses	927	981	954	2,862
Coefficient of reproducibility	.85 *	.84*	.82*	.83*

*Requires rejection of the hypothesis.

Third grade subjects

As shown in Data Table 6, third grade subjects' performances which yielded the highest coefficient of reproducibility value was not on the same sequence of conceptual relations as was that for first grade subjects. The arrows in Data Table 6 indicate those conceptual relations in sequential positions which subjects by grade level or combined performance agreed on. Third grade subjects agreed with first grade subjects on positions 1, 2, 3, and 9.

For third grade subjects the ninth hypothesis was rejected. A coefficient of reproducibility value of .84 was larger than the null hypothesis stated would be attained for this group.

Sixth grade subjects

A coefficient of reproducibility value of .82 was large enough to require that the ninth hypothesis be rejected for sixth grade subjects. Data Table 6 shows sixth grade subjects agreeing with third grade subjects on positions 1, 2, 3, 4, 5, and 9 in the sequence of conceptual relations which yielded the highest coefficient of reproducibility value for them.

Combined Subjects Performance

Combined subjects' performances yielded on the sequential order of conceptual relations found on Data Table 6 a coefficient of reproducibility value of .83 which was large enough to support rejection of the ninth hypothesis. The sequence of conceptual relations which yielded the highest coefficient of reproducibility value for combined subject responses had seven positional agreements with that of sixth grade subjects, six positional agreements with third grade subjects, and four positional agreements with first grade subjects.

Tenth hypothesis. Chronological age will not be a factor in determining which sequence of relations yields the highest coefficient of reproducibility value.

As shown in Data Table 7, no two grade level of subjects had the same relational sequence which yields the highest coefficient of reproducibility value. All three grade levels of subjects did agree on the first, second, third, and ninth relational positions. But there was enough disagreement among positions four through eight to warrant rejecting the tenth hypothesis.

Chi Square and Scalogram Analysis: Hypothesis Eleven

Eleventh hypothesis. Sex will not be a factor in determining which sequence of relations yields the highest coefficient of reproducibility value; nor will a chi square value be derived which is significant at the .05 level of statistical confidence.

Scalogram analysis

Data Table 7 on the following page shows that male and female subjects differed in positions six, seven and eight when determining which sequence of conceptual relations would yield the highest coefficient of reproducibility value. Therefore, that portion of the eleventh hypothesis dealing with scalogram analysis was rejected. As shown in Data Table 7, both sexes were within .01 for their highest coefficient of reproducibility value for their respective sequence of conceptual relations.

Chi square

To determine if the concepts used to test the Farradane model were biased toward male or female subjects' attainment of conceptual clarity, a chi square value was computed. Data Table 8 contains numerical information applied in de-

DATA TABLE 7

Sequences of Conceptual Relations Yielding the Highest Coefficient of Reproducibility Values for Males and Females

Positions	Males	Females
1	Concurrence →	Concurrence
2	Distinctness →	Distinctness
3	Appurtenance →	Appurtenance
4	Dimensional →	Dimensional
5	Self-activity →	Self-activity
6	Equivalence	Reaction
7	Reaction	Association
8	Association	Equivalence
9	Functional dependence →	Functional dependence
Scores	806	693
Errors	227	251
Responses	1386	1476
Coefficient of reproducibility	.84*	.83*

*Requires rejection of the hypothesis.

riving the chi square value. The range of scores from 0 through 9 was established when dichotomizing subjects' responses for purposes of scalogram analysis. In the study there were 154 male subjects and 164 female subjects.

DATA TABLE 8

Numerical Information Essential for Deriving Chi Square

	Males		Females		
Scores	Observed	Expected	Observed	Expected	
9	9	10	9	10	18
8	27	18	11	20	38
7	16	12	11	13	27
6	23	18	15	20	38
5	17	20	25	21	42
4	8	20	33	21	41
3	32	22	13	23	45
2	16	20	27	21	43
1	4	9	14	10	18
0	2	5	6	5	8
	154	154	164	164	318

A chi square value of 46.03 was computed. With nineteen degrees of freedom, this chi square value was significant at the .01 level of statistical confidence. Therefore, sex was a factor affecting subject performance. The eleventh hypothesis was rejected. Male subjects demonstrated more conceptual clarity for the concepts used in testing the Farradane model than did female subjects.

Data's Portents for the Study

What a man understands is largely controlled by what he believes. And, what a man questions seldom erodes the foundations of his beliefs. The power of man to question is checked by his power to rationalize. The reaction to the data's portents for this study reflects the preceding human characteristics and powers.

The statistical data obtained through factor analysis suggest that one factor was chiefly responsible for subjects' performances. This may be a result of either or a combination of the following items: (1) important variables were not sufficiently controlled; for instance, intelligence and difficulty of concepts. (2) the instrument developed did not contain questions and content which would activate factors already purportedly factored out by instruments developed by J. P. Guilford and his associates. (3) the theoretical nine conceptual relations in the Farradane model can be accounted for under one general factor. (4) the results of factor analysis is determined more by technological devices than by scientific observation.

In all probability the dominant factor which accounted for subject performance was intelligence. However, randomly selecting subjects from a stratified population should theoretically assure one that the natural ranges of intelligence among humans were included in the study. Therefore, the general factor of intelligence would have to be controlled in a manner which permitted specific factors of intelligence to emerge in a way that statistical analysis could detect them. This probably was not accomplished.

The range in difficulty of concepts is probably not a valid consideration since subject performances demonstrated that first, third and sixth grade subjects performed relatively equal on the concept machine but did not on the concept cell or bacteria. There was enough difficulty in the material used in presenting the twenty different concepts and their nine respective conceptual relations for a hierarchal order to develop for the conceptual relations. Data Table 9 which list the mean score for each of the nine subtests and t scores with their level of significance for each adjoining set of subtests verifies that the questions asked for each relation was not equally difficult. Data Table 9 is on the following page.

From the results of factor analysis, one could conclude that the instrument failed to stimulate the various factors Guilford and his associates have purportedly verified with their instruments. However, there is a possibility that the nature of the content needed to test the Farradane model does not lend itself to activating all of the operations (Cognition, Memory, Divergent Production, Convergent Production, and Evaluation) that Guilford says the intellect can perform. Therefore, the theoretical nine conceptual relations in the Farradane model doesn't even require five factors to account for the suggested nine. In fact, according to this study one will suffice. Certainly, the mean scores and t scores with their level of significance in Data Table 9 indicates that a lack of difficulty did not permit more factors from emerging.

An examination of the variations in eigenvalues and correlations raises some technological questions. Factor analysis for combined subjects was so decisive for there only being one factor than was that of the groups which make up the combined group that one wonders why the whole was so much more patently clear than were its parts. Are we quantifying naturalistic observations so statistical data will be available to generate mathematical models in abstractions which fail to describe

DATA TABLE 9

t Scores for Adjoining Subtests Ranked from Easiest to Most Difficult as Determined by Mean Scores for Each Grade Level of Subjects

Grade	Subtests	Mean Scores	t Scores	Level of Sgnfcnc.
1	Concurrence	13.96		
1	Distinctness	13.47	1.33	.2
1	Appurtenance	11.59	4.7	.001
1	Association	10.35	3.87	.001
1	Equivalence	10.26	.272	.8
1	Reaction	10.00	.722	.5
1	Self-activity	9.69	.911	.4
1	Dimensional	9.58	.290	.8
1	Functional Dependence	9.42	.347	.8
3	Concurrence	15.89		
3	Distinctness	15.46	2.15	.05
3	Appurtenance	14.31	6.7	.001
3	Dimensional	13.49	2.64	.01
3	Self-Activity	13.32	.47	.7
3	Equivalence	13.14	.580	.6
3	Reaction	12.91	.621	.6
3	Association	12.89	.05	0
3	Functional Dependence	11.66	3.72	.001
6	Concurrence	17.89		
6	Distinctness	16.95	4.7	.001
6	Appurtenance	16.49	1.9	.1
6	Dimensional	16.36	.46	.7
6	Self-activity	15.91	2.25	.05
6	Equivalence	15.46	1.6	.2
6	Reaction	15.30	.6	.6
6	Association	14.69	2.03	.05
6	Functional Dependence	14.07	1.84	.1

intelligence or learning processes? A look at the eigenvalues by grade levels and combined subjects for the nine conceptual relations in the Farradane model will show support for Eysenck's comment: "Zangwill has several times suggested that the whole intelligence testing movement is a technological rather than a scientific one, and in essence my own diagnosis is not too different from his." (1, p. 83)

DATA TABLE 10

Eigenvalues for Grade Levels and Combined Subjects

Variables	Eigenvalues			
	Grade levels			Grade levels combined
	First	Third	Sixth	
Concurrence	3.7841	3.3842	4.1000	5.9388
Self-activity	.9531	1.2412	.9634	.5394
Association	.7941	.9101	.7610	.4932
Equivalence	.7364	.7607	.7102	.4321
Dimensional	.6595	.6376	.6179	.3752
Appurtenance	.6077	.5818	.5942	.3557
Distinctness	.5681	.5624	.4630	.3091
Reaction	.4704	.4908	.4413	.2993
Functional Dependence	.4266	.4312	.3490	.2573

Take note of how the first eigenvalue (Concurrence) for grade levels combined swallowed the first two eigenvalues (Concurrence and Self-activity) for each grade level and in the process of gorging itself reduced all those directly under it to about one half of what their counterparts are under separate grade levels. Does the increment in the first eigenvalue for grade levels combined and the reduction in size for all other eigenvalues under it offer a better description of subject performance than does that of separate grade levels? The issue is to know how much of the change in eigenvalues for grade levels combined is a result of quantified observations being manipulated technologically. Without this knowledge, it is impossible to know how representative the statistical structures derived through factor analysis are of the order of mental processes adhered to in developing conceptual clarity. Perhaps Eysenck made an astute observation when he said, "I would suggest that the psychometric approach has become almost completely divorced from both psychological theory and experiment, and that factor analysis, while an extremely useful tool, cannot by itself bear the whole burden which has been placed upon it." (1, p. 83)

Of course, it can be argued that what factors emerge and the extent of their significance depend upon the situation. If factors are situationally created, then they are not descriptions of what man takes with him into situations. What is a factor? Horst wrote, "Factor analysts have traditionally used the word factor to mean some sort of theoretical or hypothetical variable, whereas mathematicians use it to mean one of a number of things which when multiplied together give a product." (2, p. 4)

Perhaps mathematicians' definition of factor has more meaning for the nine stages of conceptual clarity suggested in the Farradane model than does factor analysts' use of the term. Substitute the words added for multiplied and sum for product and it makes sense for the Farradane model. That is, each conceptual relations understood by a person for a given concept adds to his sum of conceptual clarity for that concept. If each of the nine conceptual relations is accepted as being addends which increase conceptual clarity, then it would be useful to establish a hierarchal seriatim for the nine. A seriatim which implies that if a person has attained for a specified concept an understanding of the second conceptual relation in the sequence then embedded in it is an understanding of the first conceptual relation. That is, embedded in a two dollar bill is the value of a one dollar bill.

Scalogramming subjects' responses to the nine different conceptual relations suggested that a hierarchal seriatim can be established. At this point of the reaction to the data's portents for the study, it would be meaningful to compare the rank order of the nine subtests in the instrument based on highest to lowest mean score and the sequences of conceptual relations which yielded the highest coefficient of reproducibility value for both separate grade levels of subjects and combined grade levels. For grade levels of subjects, Data Tables 6 and 9 contain the essential information required for the comparisons.

First grade subjects

	Mean Score Hierarchy		Scalogram Analysis Hierarchy	
mean score				credit frequency
13.96	Concurrence	↔	Concurrence	91
13.47	Distinctness	↔	Distinctness	84
11.59	Appurtenance	↔	Appurtenance	57
10.35	Association		Equivalence	39
10.26	Equivalence		Dimensional	35
10.00	Reaction		Self-activity	30
9.69	Self-activity		Association	29

mean score				credit frequency
9.58	Dimensional		Reaction	25
9.42	Functional Dependence	↔	Functional Dependence	16

As can be seen for first grade subjects there are only four positional agreements between the two hierarchies. Apparently the loss of data through dichotomizing the responses for scalogram analysis affect the hierarchal sequence.

Third grade subjects

	Mean Score Hierarchy		Scalogram Analysis Hierarchy	
mean score				credit frequency
15.89	Concurrence	↔	Concurrence	87
15.46	Distinctness	↔	Distinctness	74
14.31	Appurtenance	↔	Appurtenance	50
13.49	Dimensional	↔	Dimensional	47
13.32	Self-activity	↔	Self-activity	38
13.14	Equivalence		Association	29
12.91	Reaction	↔	Reaction	27
12.89	Association		Equivalence	25
11.66	Functional Dependence	↔	Functional Dependence	14

Third grade subjects have agreement among seven of the positions in the two hierarchies. This could be an indication of third grade subjects having greater conceptual clarity than first grade subjects. Therefore, the loss of data through dichotomizing third grade responses had less effect on a mean score hierarchy than it did for first grade subjects. It should be remembered that that criteria for dichotomizing first grade responses was different from that for third grade. First grade subjects had to get twelve or more responses correct out of twenty chances to receive credit while it was fifteen out of twenty for third grade subjects. The rationale for this is in Chapter II.

Is it possible that because more of the conceptual relations tested on concepts used in the study are more firmly entrenched in third grade subjects repertory of knowledge that higher criteria for credit still did not cause as much difference between positional agreements? Perhaps a continued increment in conceptual clarity for sixth grade subjects over that of third grade subjects more firmly establishes a seriatim of conceptual relations acquired in developing conceptual clarity.

Sixth grade subjects

Mean Score Hierarchy			Scalogram Analysis Hierarchy	
mean score				credit frequency
17.89	Concurrence	↔	Concurrence	104
16.95	Distinctness	↔	Distinctness	91
16.49	Appurtenance	↔	Appurtenance	92
16.36	Dimensional	↔	Dimensional	88
15.91	Self-activity	↔	Self-activity	78
15.46	Equivalence		Reaction	73
15.30	Reaction		Equivalence	67
14.69	Association	↔	Association	57
14.07	Functional Dependence	↔	Functional Dependence	48

Although sixth grade subjects have only seven positional agreements between the two hierarchies, the disagreements adjoin each other. That is, a switch in positions of either up or down one slot would remove the disagreement. Again, there is evidence that greater conceptual clarity possessed by sixth grade subjects brought the two hierarchies more into accord. It seems as conceptual clarity increased disagreements decreased.

It is interesting to examine the range in the various grade levels between the conceptual relation receiving the highest number of credits and the one receiving the lowest number of credits. They are:

	Highest Credit Concurrence	Lowest Credit Functional Dependence
First grade	91	16
Third grade	87	14
Sixth grade	104	48

It can be inferred from information on Data Table 9 that scores between these two subtests would be significant at the .001 level of confidence. Third grade subjects' range is not much different from that of first grade subjects due to different criteria used for these two groups in dichotomizing their responses. However, the difference in range for sixth grade subjects from that of third and first grades certainly indicates more conceptual clarity for sixth grade subjects.

Before discussing the mean score hierarchy and the scalogram analysis hierarchy for combined subject performance, the t scores for the different subtests should be presented. Data Table 11 on the following page contains the mean score and their t scores. Under Data Table 11 is presented the mean score and scalogram analysis hierarchies for combined subjects' performances.

DATA TABLE 11

t Scores for Adjoining Subtests Ranked from Easiest to Most Difficult as Determined by Mean Scores for Combined Subjects' Performances

Sub-tests	Mean Scores	t Scores	Level of Significance
Concurrence	15.96		
Distinctness	15.30	3.88	.001
Appurtenance	14.15	5.75	.001
Dimensional	13.18	3.46	.001
Self-activity	13.01	.56	.6
Equivalence	13.01	0.0	.0
Reaction	12.74	1.1	.3
Association	12.67	.29	.8
Functional Dependence	11.74	3.87	.001

Combined grade levels

mean score	Mean Score Hierarchy		Scalogram Analysis Hierarchy	credit frequency
15.96	Concurrence	↔	Concurrence	282
15.30	Distinctness	↔	Distinctness	249
14.15	Appurtenance	↔	Appurtenance	199
13.18	Dimensional	↔	Dimensional	170
13.01	Self-activity	↔	Self-activity	146
13.01	Equivalence	↔	Equivalence	131
12.74	Reaction	↔	Reaction	128
12.67	Association	↔	Association	115
11.74	Functional Dependence	↔	Functional Dependence	78

For combined performances the two hierarchies are in positional agreement. Perhaps combining first, third, and sixth grade subjects' responses gave the study a longitudinal perspective in which is indicated the sequence of relations one follows in developing clarity for a concept. Although the subtests for Self-activity and Equivalence have the same mean scores, they both do not have the same credit frequency in scalogram analysis. Therefore, Self-activity comes before Equivalence in the seriatim because it had a higher credit frequency.

The strong positions of the conceptual relations of Concurrence, Distinctness, Appurtenance, and Functional Dependence in the seriatim is supported by each grade level agreeing on them, male, and female subjects agreeing on them, and t scores for them being significant at the .001 level of confidence.

Scalogram analysis and t scores for the subtests are far more supportive to the hypothesis that the Farradane model offers a basis upon which may be developed a strategy for directing conceptual attainment than was factor analysis. However, separate entities in a model do not have to be proven to be separate factors before they have value for instructional purposes. The nine conceptual relations, as suggested by scalogram analysis, apparently form a unidimensional scale which can be very valuable in directing the acquirement of conceptual clarity. Educators would do well to follow a unidirectional course in guiding students to develop conceptual clarity. Let those interested in psychometrics fret over the number of factors involved in students achieving conceptual clarity while teachers direct it.

The contents of chapter four offers a model which give educators extended direction to follow in guiding students to develop greater conceptual clarity. The data obtained through this study did not yield a theoretical statistical structure which would support the suggested model unquestionably. The results of factor analysis would indicate that the retaining of the mental operations suggested by Farradane to be responsible for generating a knowledge of conceptual relations is indefensible. However, since Guilford has purportedly verified five of them (Cognition, Memory, Divergent Production, Convergent Production, and Evaluation) through use of instruments he and his associates have developed, they are retained for the following reasons: (1) no concerted effort was made in this study to actually determine if the realization of say distinctness was dependent upon the mental operations of Cognition and Divergent Production as proposed in the Farradane model; nor were any of the other conceptual relations studied to determine if they were products of two mental operations jointly generating a knowledge of them. (2) this was an explorational study which did not investigate all of the psychological implications of the Farradane model. (3) retention of them in the suggested model offers further opportunity to explore their meaning and significance in developing conceptual clarity through use of instruments or techniques which may produce data more sensitive to statistical verification of these specific factors. (4) the eigenvalues for separate grade level performances were not as decisive for there only being one factor predominantly controlling subjects' responses as there was for combined grade level performances. Therefore, they were retained until a more sophisticated study helps determine if the content needed in testing the Farradane model requires these mental operations. Man is using neither his power to question or to rationalize if he permits his first attempt to discover knowledge to produce a dead end road too inflexible to be extended through curving around obstacles first experiences often seem to generate.

The results of scalogram analysis offers the flexibility this study needs to support questioning and rationalizing which will maintain interest in it. Scalogram analysis supported by t scores for adjoining subtests in the hierarchy of conceptual relations ranked from easiest to most difficult offer sufficient data to warrant a belief that the nine conceptual relations identified in the Farradane model may provide a strategy for educators to follow in directing the development of conceptual clarity. This data while supportive to the idea that the nine conceptual relations form a unidimensional scale does not eliminate the possibility of two mental operations reacting jointly on a stimulus to bring an understanding of a specific conceptual relation in a unidimensional scale to fruition. A unidimensional scale which contains activities that require mental operations to generate does not necessarily lose its quality unidimensionality due to the necessity of intellectual function.

The contents of chapter four is a result of the reaction to the portents the data of this study offered. The reaction was one of bringing the powers to question and to rationalize to the portents of the data which results in a conclusion that does not end a commitment to a search for a strategy to follow in directing the development of conceptual clarity.

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CHAPTER IV

CONCLUSIONS AND SUGGESTIONS

The hypotheses which stated the criteria by which the Farradane model would be evaluated have indicated that the nine conceptual relations can be a basis upon which to develop a strategy to follow in teaching concepts. Certainly, subjects' responses through scalogram analysis showed that what Carroll described as being " . . . the public test of the formation of a concept . . . " (2, p. 181) is not enough for a teacher to apply in determining whether a student had attained clarity of a given concept. In fact, subjects' responses to questions based upon conceptual relations associated with positive and negative instances of concepts received a greater frequency of credit than did those based upon conceptual relations requiring more subtle appreciation of why particular phenomenon receive a certain classification.

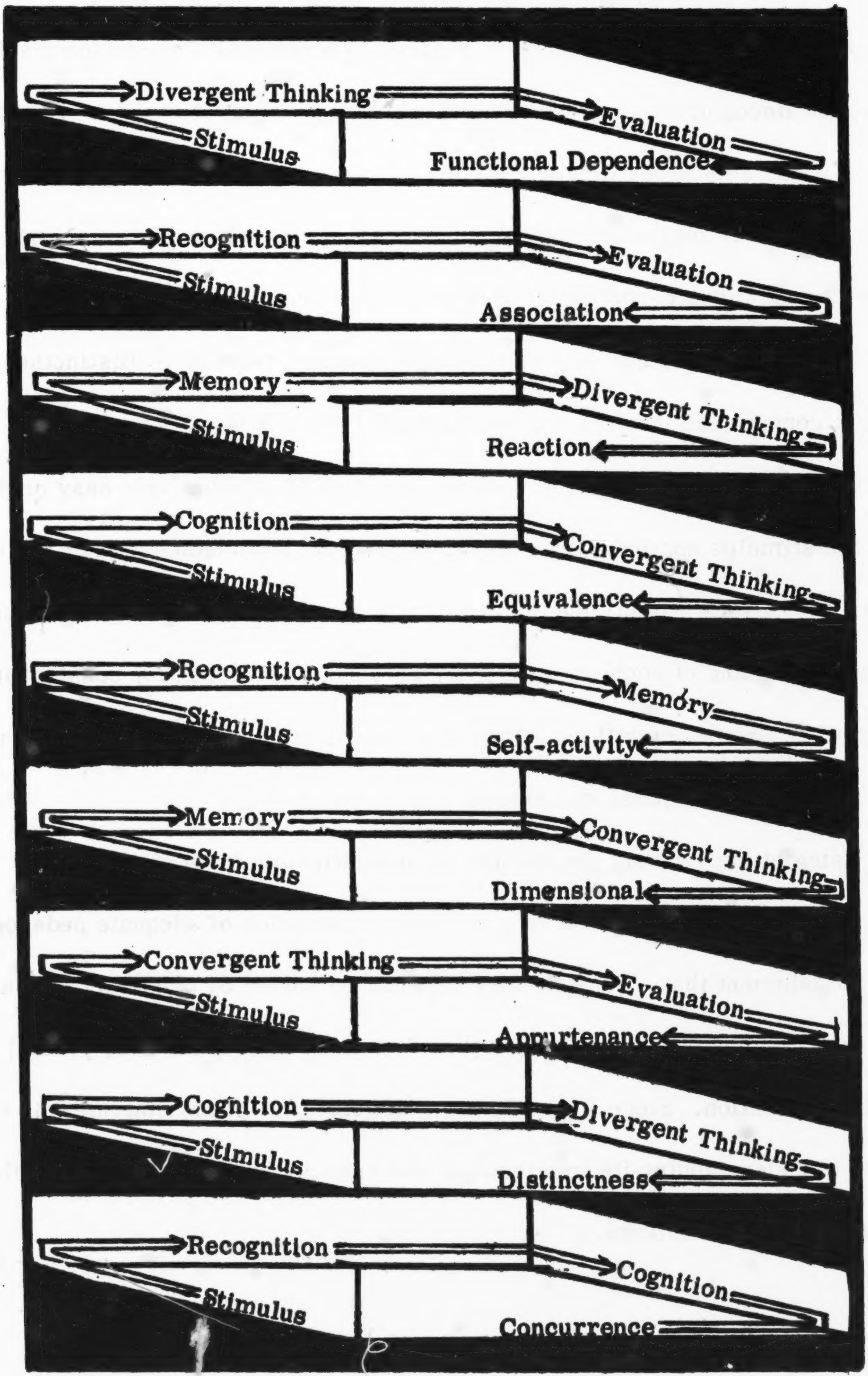
Too often, positive and negative instances stimulate only mental activities relegated to the level of what Bloom referred to as knowledge in his "Taxonomy of the Cognitive Domain." Perhaps perceptual stimuli required for positive and negative instances of a concept fail to activate an intellect beyond mere awareness. Therefore, relying entirely upon positive and negative instances to direct concept formation and to determine concept attainment results in minimal mental involvement. Such a superficial approach for directing concept development lessens the teacher's chances of meeting the following challenge described by Carroll: "Often the task that presents itself to the teacher is not merely to explain a new word in familiar terms, but to shape an entirely new concept in the mind of the student." (1, p.178)

To shape an entirely new concept in the mind of a student requires a strategy which will provide the teacher with direction and the diagnostical tools essential for evaluating progress; a strategy which will make formal education an effective catalyst in accelerating the natural learning process with which man is endowed.

In the initial stages of developing a strategy to apply in the teaching of concepts, the following model, "The Hierarchal Relations Essential for Increasing Conceptual Clarity," is presented. This model is a reordering of the conceptual relations and mental operations found in the Farradane model. This reordering was suggested by the data produced through scalogram analysis. It is based upon the combined performances of first, third, and sixth grade subjects. Results of combined subjects' performances were chosen because of the longitudinal perspective they may offer. The mental operations suggested by Farradane to be responsible for generating the knowledge of the various conceptual relations were retained as a theoretical proposition which is yet to be verified. However, their presence does not necessarily negate the unidimensional characteristics attributed to the nine conceptual relations offered through scalogram analysis. In fact, they only suggest how the intellect reacts to stimulus which helps students to develop more conceptual clarity.

Data obtained through scalogram analysis of combined subjects' responses, while being very supportive to a unidimensional scale, also confirmed the first, second, third, and ninth positions of conceptual relations as being common to first, third, and sixth grade levels of subjects in terms of being either easy or difficult. Based on subjects' response patterns, the coefficient of reproducibility value for

The Hierarchal Relations Essential
for
Increasing Conceptual Clarity


Divergent Thinking
Stimulus
Evaluation
Functional Dependence
Recognition
Stimulus
Evaluation
Association
Memory
Stimulus
Divergent Thinking
Reaction
Cognition
Stimulus
Convergent Thinking
Equivalence
Recognition
Stimulus
Memory
Self-activity
Memory
Stimulus
Convergent Thinking
Dimensional
Convergent Thinking
Stimulus
Evaluation
Appurtenance
Cognition
Stimulus
Divergent Thinking
Distinctness
Recognition
Stimulus
Cognition
Concurrence

the suggested model is .83. This is acceptable for sustaining interest until more affirmative or negative data are obtained.

To interpret the model one would begin with the conceptual relation Concurrence. Concurrence depends upon a Stimulus which will activate the mental operation of Recognition which evokes the mental operation of Cognition, thereby resulting in the subject's experiencing this conceptual relation. This basic sentence reads for all suggested stages in the model when the conceptual relation and the mental operations essential for its occurrence are substituted.

Before a subject can experience the conceptual relation of Distinctness for a specific concept, he must be capable of cognitively producing Concurrence for that concept through responding to a stimulus which is as relatively easy or difficult as the stimulus applied in attempting to generate Distinctness. For a given concept, the various stimuli used in developing the nine relations should be on a fairly uniform plane of sophistication. If the stimuli are not fairly constant in formidability, the model will not serve as a source from which to develop a strategy for directing conceptual attainment.

Using stimuli having consistency in sophistication for a given concept is not a limitation of the model. It is a realistic expectation of adequate pedagogy. Bruner's statement that, "Any problem that can be solved by presently available means can be solved by simpler steps than those now employed," (1, p. 201) supports this contention. Since Bruner's own interpretation of his statement is contributive to understanding its implications and ramifications for the model, the complete explanation follows.

> Any problem that can be solved by presently available means can be solved by simpler steps than those now employed. . . . Any structure of propositions that effect a productive simplification of a body of knowledge can, similarly, be restated in a simpler form that is both powerful and effective in the sense of being within reach of a learner. The translation may lose in power or precision, but it will still be simplifying and generative -- and its gain will be effectiveness for the user. The inventive task of the teacher or curriculum-maker is to find the translation of propositions that is appropriate to the powers of the person being asked to master it. . . . Any subject, in short, can be taught to anybody at any age in some form that is honest and useful. The burden of proof is upon those who teach, as well as those who learn. . . . (1, pp. 201-02)

Perhaps an analogy of the proposed model to a mechanical tool will suggest how educators may use the model as a tool in assuming the burden of proof that any concept can be taught to anybody in some form that is honest and useful. In the vernacular of a mechanic, the model would become a speeder handle with adjustments for nine different sockets. The sockets would be stimuli; the nuts the sockets fit would be the first mental operation required for conceptual relations which are activated by stimuli. The bolts would be the second mental operation which brings the conceptual relations to full fruition. The nut and bolt would jointly hold together the conceptual relation sought after. The model is a speeder handle offered to teachers and producers of educational materials which, if applied, will tax their inventiveness in developing stimulus materials which will accelerate the development of any concept for anybody. In preparing the stimulus materials, it must be remembered that the student has the nut which the socket must fit if the speeder handle and the socket are going to be useful.

The rationale for the sequence of the conceptual relations and the mental operations which generate them will offer more insight into the model. The terminology used will have the same definitions given in Chapter I.

The sequence begins with the conceptual relation Concurrence because a student must be aware that the phenomenon which is the basis of a given concept has a separate and definable identity which sets it apart from all other concepts. The initial awareness of this unique identity is the mental operation of Recognition in action, alerting the mental operation of Cognition when phenomenon for a new classification unit is being perceived. The mental operation of Cognition responds by recording the unique characteristics which identify the phenomenon as warranting a separate classification unit. With this storage of information in a new unit, a basis has been established which will make the conceptual relation Distinctness possible.

Distinctness is generated when a stimulus activates the mental operation of Cognition which, through retrieval of recorded information, alerts the student to what is in the classification unit. The mental operation of Divergent Thinking contrasts the information to the stimulus presently being perceived, seeking to establish if it belongs to this classification unit. If it does not, the conceptual relation Distinctness has been experienced.

With the knowledge created by experiencing the conceptual relations Concurrence and Distinctness, a student can generate the conceptual relation Appurtenance by examining a stimulus and applying Convergent Thinking to determine if the stimulus has those peculiar and sometimes subtle characteristics which require a certain classification. Then, the mental operation of Evaluation decides if those characteristics identified through Convergent Thinking qualify the stimulus for the particular classification.

The conceptual relation Dimensional requires a stimulus which will activate the mental operation of Memory which scans across several sub-cognitive classification units, retrieving only that information which will aid in determining the dimensional range of items assigned to the broader classification unit. With the information Memory brings forth, Convergent Thinking seeks the best answer which indicates the dimensional range. Awareness of Appurtenance makes this task easier because it may have already been determined if size or state is a characteristic pertaining to Appurtenance. Furthermore, visibly or mentally examining members of a category for unique and subtle characteristics affords an opportunity to become aware of their range in sizes.

Self-activity is a conceptual relation which requires a stimulus causing a more sophisticated function of the mental operation of Recognition than that in Concurrence. Here the stimulus must be one which causes the student at first glance to link an activity with an already known subject. Then, the student calls upon the mental operation of Memory to confirm that, indeed, this activity is peculiar to this subject and members of this category. Therefore, knowing the relations of Appurtenance and Dimensional gives a student experience which tells him if the activity is closely related to Appurtenance and if Dimensional has any control on activity.

If a student can functionally manipulate the preceding five conceptual relations, he is in a position to generate the conceptual relation Equivalence after a proper stimulus has been applied. This requires the mental operation of Cognition, which updates the student as to what he is aware of, and the mental operation of Convergent Thinking, which applies what he is aware of to the one best answer which, in this case, determines if the objects in question are the same based on specified criteria.

With the exception of the Divergent Thinking required for Distinctness, the first six relations are basically intra-concept oriented. The last three are inter-concept oriented. The relation Reaction calls for seeing an effect one concept has on another or how a concept is affected by another. For this, the stimulus should evoke the mental operation of Memory to recall experiences which are pertinent to interrelations of concepts. Through the process of Divergent Thinking, the student can extend his thoughts to another concept and determine the effect interaction of concepts has on a given concept.

Association, like Reaction, requires an awareness of relationships between concepts. However, this awareness extends to understanding the causes as well as the effects resulting from the relationship. By understanding the conceptual relation Reaction, a student needs only the mental operation of Recognition to see that there is a relationship. With this awareness, he applies the mental operation of Evaluation to ascertain the results of the cause and effect partnership between the two concepts.

Functional Dependence requires that a student apply all he has learned from the other relations. In determining upon what the phenomenon behind a concept is dependent, a student first applies Divergent Thinking which directs him away from the phenomenon toward a source which may be the generator of the phenomenon. After locating the source, he evaluates the circumstances to verify the causational or dependent relationship.

Certainly, this model is not the final word in concept teaching. More aptly, it is the first contribution from a writer who would like to offer and see more and better strategies for concept teaching. The model offers a synthesis of what has been known for years to be essential in concept learning. If the model, and the strategy it offers, are in the class of contributions, it is because the model, based upon student responses, suggests a sequence of conceptual relations which increases conceptual clarity. Teachers, through a querying or probing technique, could determine how much clarity a student has achieved in a given concept, based upon gradient materials. For diagnosis, the teacher would begin questioning the student to determine if he has attained an understanding of Functional Dependence, the most difficult of the conceptual relations. She would stop with the first question the student answered correctly. The teacher then would begin instruction which leads back to an understanding of Functional Dependence. Of course, if the student answered the question for Functional Dependence correctly, the teacher would move to more difficult material and establish the point of conceptual clarity achieved at that level. Thus, the model offers a strategy which aids the teacher in achieving the goal of student understanding of all the conceptual relations.

The analyses of subjects' responses according to grade level revealed no agreement on the order of difficulty for those conceptual relations in positions four, five, six, seven, and eight. More research is needed to determine the exact order of these conceptual relations per grade level. However, those relations in positions one, two, three, and nine in the model have been confirmed by first, third, and sixth grade subjects' performances as being the same for these three grade levels.

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APPENDICES

APPENDIX A

DESCRIPTIVE COPY OF THE INSTRUMENT

Instructions: Say to the student --

I am going to ask you some questions about food, animals, fruit, electricity, trees, machines, and so on. You will have four pictures from which to choose your answer to each question I ask. If you do not know what any picture is, please ask me. I will tell you what it is. During the questioning, I will remind you that you may ask me questions about the pictures.

When you have chosen the picture you want to answer a question, just point to it or tell me the number of it. I will mark your answer on the answer sheet. Remember that there is no grade given for this exercise.

These are the kind of pictures you will be using. Look at these pictures and choose the one that has two cows. Yes, number four has two cows.

Questions to be Asked on the Concept ANIMAL

1. Which picture shows an animal?

a. A flower and a can
b. A flower and a bee
c. A flower and a rock
d. A flower and a brook

2. Which picture best shows what all animals do?

a. A boy running, a bird flying, and a fish swimming
b. A boy, fish, and bird holding up the world
c. A boy, bird, and fish reading
d. A bird, fish, and boy flying

3. Which picture makes you think of all kinds of animals?

a. A fur rug
b. A green plant
c. A water faucet filling a glass
d. A human arm bleeding

4. Which picture shows two kinds of animals?

a. A leaf and a worm
b. A cow and a nest of eggs
c. A man on a horse
d. A bird on a statue

5. Which pair of circles best shows from how small to how large animals may be?

a. From 1/2" to 5/8" diameter
b. From 1/2" to 1 5/8" diameter
c. From 1 5/8" to 1 5/8" diameter
d. From 1" to 1 5/8" diameter

6. Which picture best shows what all animals have?

a. Skin
b. Bone
c. Hair
d. Teeth

7. Which picture does not show a real animal?

a. A baby
b. Toy dog on wheels
c. A dog
d. A butterfly

8. Animals do more to plants than eat them. The air breathed out by animals does something for plants. Which picture best shows how air breathed out by animals affects plants?

a. A healthy plant
b. A dead plant
c. A worm-eaten plant
d. A withered plant

9. Which picture shows the source of food for animals?

a. Fire
b. Milk
c. Meat
d. A plant

REMEMBER, IF YOU HAVE QUESTIONS ABOUT THE PICTURES, YOU MAY ASK ME WHAT THEY ARE.

Questions to be Asked on the Concept MAMMAL

1. Which picture shows a mammal?

a. An ostrich
b. Alligator
c. Butterfly
d. Man

2. Which picture shows something only mammals do?

a. Boy climbing a tree
b. Calf nursing
c. Boy swimming
d. Deer running

3. Which picture makes you think of mammals?

a. An egg
b. Glass of milk
c. Larva
d. Head of a fish

4. Which picture shows two kinds of mammals?

a. Man and a bird
b. Man and a fish
c. Man and a cat
d. Man and a snake

5. Which two animals best show from how small to how large mammals may be?

a. Whale and a small mouse
b. Whale and an elephant
c. Elephant and a cow
d. Boy and an ape

6. Which picture shows something found on mammals?

a. Scales
b. Feathers
c. Shells
d. Hair

7. What picture does not show a mammal?

a. Bat
b. Polar bear
c. Ostrich
d. Platypus

8. Which picture best shows what mammals do to plants?

a. Man spraying a plant
b. Fire burning plants
c. Cow eating grass
d. Man resting under a shade tree

9. Which picture best shows what mammals need if there are going to be new or baby mammals?

a. A cow and a horse
b. A cow and a bull
c. Two bulls
d. Two cows

Questions to be Asked on the Concept REPTILE

1. Which picture shows a reptile?

   a. Fly
   b. Turtle
   c. Pig
   d. Bird

2. Which picture shows what some reptiles do during cold weather?

   a. Snakes hibernating
   b. Alligator flying south
   c. Lizard eating ice cube
   d. Turtle laying eggs in the snow

3. Which picture makes you think of reptiles?

   a. Cold blustery scene
   b. Fall scene
   c. A dead tree
   d. A tropical scene

4. Which picture shows two kinds of reptiles?

   a. A fish and alligator
   b. A lizard and a bird
   c. A crocodile and a snake
   d. A snake and a worm

5. Which pair of circles best shows how small and how large reptiles may be?

   a. A circle 1/2" in diameter and one 1 5/8" in diameter
   b. Two circles 1/2" in diameter
   c. One circle 1 1/4" in diameter and one 1 5/8" in diameter
   d. Two circles 5/8" in diameter

6. Which picture shows the number of legs on those reptiles having legs?

   a. Two reptile legs
   b. Six reptile legs
   c. Four reptile legs
   d. Four eyes

7. Which picture does not show a reptile?

   a. A frog
   b. An alligator
   c. A lizard
   d. A turtle

8. Which picture makes you think of what some reptiles could do to man?

   a. A turtle scrubbing a man's back
   b. A casket with flowers on it
   c. A lizard fanning a man
   d. A turtle reading to a man

9. Which picture shows the type of weather a reptile needs if he is to be active?

   a. The arctic area
   b. A hot dry desert area
   c. Cold windy area
   d. Warm moist area

REMEMBER, IF YOU HAVE QUESTIONS ABOUT THE PICTURES, YOU MAY ASK ME WHAT THEY ARE.

Questions to be Asked on the Concept INSECT

1. Which picture shows an insect?

   a. A bird
   b. A bee
   c. A clam shell
   d. A tadpole

2. Which picture shows what insects do?

   a. Insects knitting
   b. Insects having a barbecue
   c. Insects eating leaves and cloth
   d. Insects spraying a plant

3. Which picture makes you think of an insect?

   a. A garden
   b. A bird's nest
   c. A spider web
   d. A cocoon

4. Which picture shows two kinds of insects?

   a. A butterfly and a grasshopper
   b. A grasshopper and a shrimp
   c. A butterfly and a hummingbird
   d. A dragonfly and a spider

5. Look at these circles. Pretend the largest circle is the size of a baseball and the smallest the head of a pin. Which pair best shows how small and how large insects may be?

a. Two circles 2" in diameter
b. One circle 1/8" in diameter and one 3/4" in diameter
c. Two circles 1/2" in diameter
d. Two circles 1/8" in diameter

6. Which picture best shows what the body of an insect looks like?

a. Midsection of a human
b. Abdomen of an insect not in sections
c. Abdomen of an insect in sections
d. Midsection of a worm

7. Which picture does not show an insect?

a. A grasshopper
b. A bee
c. An ant
d. A worm

8. Which picture shows how insects are harmful to man?

a. Worms eating lettuce and a mosquito stinging a boy
b. A wasp by a nest and a silkworm
c. Termites eating a board and insects flying around a tree
d. A bird eating an insect and a frog catching a dragonfly

9. If there are to be new or baby insects, which picture best shows what must come first?

a. Rocks on the ground
b. A beetle laying eggs on a leaf
c. A rose bush
d. Birds flying

Questions to be Asked on the Concept HUMAN

1. Which picture shows a human?

a. Monkey in a tree
b. Baby laying on its back
c. A cow
d. A deer running

2. Which picture shows something only humans do?

a. Man walking
b. Man sleeping in a hammock
c. Man lifting cinder blocks
d. Man reading a book

3. Which picture makes you think of humans?

a. A cage
b. A log
c. A human dwelling
d. A dog house

4. Which picture shows two humans?

a. A boy and a girl
b. A boy and a dog
c. A girl and a doll
d. A boy and a tin soldier

5. Look at the picture of the house in number one. See how tall it is. Look at all of its parts. Which line in two, three, or four best shows in comparison to the house in number one how tall a grown human is?

a. A house with a 3/4" door
b. A line 2 1/2" tall
c. A line 3/4" tall
d. A line 1 5/8" tall

6. Which picture shows something seen on humans?

a. Grass
b. Clothes
c. Leaves
d. Boards

7. Which picture does not show a human?

a. A man
b. A woman
c. A mermaid
d. A baby

8. Which picture shows human effect on the earth?

a. A natural stream of water
b. A canal
c. A natural lake
d. A natural waterfall

9. Which picture shows what humans need to live?

a. Rocks
b. An empty glass
c. Water running from a faucet to a glass
d. A fish

REMEMBER, IF YOU HAVE QUESTIONS ABOUT THE PICTURES, YOU MAY ASK ME WHAT THEY ARE.

Questions to be Asked on the Concept FOSSIL

1. Which picture shows a fossil?

a. A statue of a man
b. Cow skeleton on a desert
c. Human tracks on a beach
[✓ d. Standing dinosaur skeleton]

2. Which picture shows what fossils have helped man understand?

a. Car
b. House
[✓ c. Dinosaur]
d. Tree

3. Which picture makes you think of a fossil?

[✓ a. An old dead tree standing]
b. A small young tree sprouting green leaves
c. A medium sized young tree with green leaves
d. A large tree with green leaves

4. Which picture shows two fossils?

a. Two rocks and a dog with a bone in his mouth
b. A stone with a skeleton impressed in it and 3 arrowheads
[✓ c. A stone with imprints of a fern leaf and a trilobite in it]
d. A standing dead tree trunk and a petrified dead log nearby

5. Which pair of circles best shows how small and how large fossils may be?

[✓ a. Two circles: smallest - 1/4" in diameter; largest - 1 1/4" in diameter]
b. Two circles: both 1/4" in diameter
c. Two circles: both 1 1/4" in diameter
d. Two circles: smallest - 3/4" in diameter; largest - 1 1/4" in diameter

6. Which picture shows what most fossils are like?

a. Three maple leaves
b. A rectangular board
[✓ c. Two rocks]
d. Block of ice

7. Which picture does not show a fossil?

   a. *Human tracks on a beach*
   b. Two leaf-like imprints in a rock
   c. A leaf imprint in a rock
   d. A shell imprint in a rock

8. Which picture shows what fossils could tell man about?

   a. A futuristic-looking machine
   b. *A cave man in a cave by a fire*
   c. A modern home
   d. An old railroad in a desert

9. Which picture best shows what had to be or exist before fossils were possible?

   a. *A picture of a cow, rabbit, and plants representing life*
   b. A rainstorm
   c. Clouds, wind, and green grass
   d. An active volcano

Questions to be Asked on the Concept PLANT

1. Which picture shows a plant?

   a. *A mushroom*
   b. Deer antlers
   c. A puppy
   d. A cave

2. Which picture shows something a plant does?

   a. A plant crying
   b. A plant reading
   c. A plant growing with the top in the ground
   d. *A plant growing upward*

3. Which picture makes you think of a plant?

   a. A rock
   b. *A piece of lumber*
   c. A pane of glass
   d. Some pipes

4. Which picture shows two plants?

   a. A cactus and barbed wire
   b. A rose and a rock
   c. *A flowering bush and a tree*
   d. Grape vines and an apple

5. Which pair of lines best shows how short and how tall plants may be?

   a. One line 3/8" tall and one 1/2" tall
   b. One line 1/8" tall and one 2 1/2" tall
   c. One line 2 1/2" tall and one 1 1/4" tall
   d. Two lines 1 5/8" tall

6. Which picture shows something seen on most plants?

   a. Leaves
   b. Hair
   c. An apple, banana, and orange
   d. A bird's nest

7. Which picture does not show a plant?

   a. A cactus
   b. A room with green carpet
   c. A pond with algae in it
   d. Grass

8. Which picture shows what plants give man?

   a. A plate with several kinds of food
   b. An empty glass
   c. Metal pipes
   d. A block of ice

9. Which picture best shows what a plant needs to grow?

   a. A farmer with a pitchfork
   b. A cultivated field
   c. A cow
   d. A tractor

REMEMBER, IF YOU HAVE QUESTIONS ABOUT THE PICTURES, YOU MAY ASK ME WHAT THEY ARE.

Questions to be Asked on the Concept TREE

1. Which picture shows a tree?

   a. Short grass
   b. A bush
   c. A tree
   d. Tall grass

2. Look at the tree in the first square. Pretend that the pictures in two, three, and four are the same tree a year later. Which of these pictures best shows what trees do?

a. A tree as tall as the line
b. A tree shorter than the line
c. A tree taller than the line
d. A tree as tall as the line

3. Which picture makes you think of a tree?

a. A brick house
b. A frame house
c. A tepee
d. An igloo

4. Which picture shows two trees?

a. A pine tree and a flowering tree
b. A flowering tree and rose bush
c. An oak tree and tall grass
d. A palm tree and pampas grass

5. Look at the picture of house in the first square. See how tall it is. Which of the lines in two, three, or four best shows how tall a grown tree would be in comparison to the house in the first square?

a. A 2 1/2" house
b. A line 1" high
c. A line 1 1/4" high
d. A line 3" high

6. Which picture shows something seen on trees?

a. A log with bark
b. Hair
c. Human skin
d. A piece of skin with scales

7. Which picture does not show a tree?

a. A willow tree
b. A cypress tree
c. A tall cactus plant
d. A cottonwood tree

8. Which picture shows what man may get from trees?

a. A field
b. A car
c. A brick house
d. A frame house

9. If there are going to be new trees, which picture best shows what must first be?

   a. Birds
   b. Grass
   c. Man planting a small tree
   d. Acorn seeds on the ground

Questions to be Asked on the Concept FOOD

1. Which picture of a plate shows nothing but food on it?

   a. A plate with a carrot and potato and small pebble on it
   b. A plate with just food on it
   c. A plate with grapes, bread, a stick of wood and sand on it
   d. A plate with cheese, toast and jam, a piece of paper and a mouse on it

2. Which picture shows food doing something without the help of man?

   a. Food being eaten by a boy
   b. A steak frying in a pan on a stove
   c. A rotting potato and molding bread
   d. Peas cooking in a pot on a stove

3. Which picture makes you think about food?

   a. A kitchen
   b. A bedroom
   c. A living room
   d. A screened-in porch

4. Which picture shows two kinds of food?

   a. Meat and a refrigerator
   b. Apples on a tree and a basket of apples
   c. A field of lettuce and tomatoes
   d. A head of cabbage and a knife

5. Which picture makes you think of a size of food needed by all men?

   a. A shovel
   b. An empty drum
   c. A garbage can
   d. A spoon

6. Which picture best shows what food must be like for man to eat it?

   a. A knife cutting into a loaf of bread
   b. A table with a cloth on it
   c. A loaf of bread breaking a knife rather than the bread being cut
   d. Picture of dishes

7. Which picture shows something man would not use as a food in our country?

   a. A cow
   b. A field of tomatoes
   c. A monkey
   d. Chickens

8. Look at the picture of the boy in the first square. Pretend that the line in one is in the same place in two, three, and four. Pretend that it is the same boy a year later in two, three, and four. Which best shows the effects of the boy eating food for a year?

   a. A boy as tall as the line
   b. A boy shorter than the line
   c. A boy as tall as the line
   d. A boy taller than the line

9. Which picture shows who or what would decide a potato is a food to be bought?

   a. A man
   b. Rain
   c. An ape
   d. A tractor

Questions to be Asked on the Concept FRUIT

1. Which picture shows fruit?

   a. Potatoes
   b. Dried beans
   c. Oranges
   d. Lettuce

2. Which picture shows something fruit does by itself?

   a. Fruit sprouting
   b. A series of pictures showing an apple getting ripe
   c. Fruit shooting upward from a fruit tree
   d. A picture of apples falling from the tree towards and into a box which is not under the tree

3. Which picture makes you think of fruit?

a. A glass of grape juice
b. A cup of coffee
c. A glass of milk
d. A jar of honey

4. Which picture shows two kinds of fruit?

a. A pear and potato
b. An apple and a watermelon
c. An orange and a blossom
d. A bunch of grapes and a peanut

5. Look at the picture of the bass drum in the first square. In comparison to this drum, which pair of circles best shows how small and how large fruit may be?

a. Bass drum 3 1/4" in diameter
b. One circle 3 1/4" in diameter and one 1/4" in diameter
c. Two circles 2" in diameter
d. One circle 1/8" in diameter and one 1" in diameter

6. Which picture shows something most fruit has?

a. A red apple
b. An apple, orange, and grapes with juice falling from them
c. Circle of yellow color
d. A tree

7. Which picture does not show fruit?

a. Watermelon
b. Plums
c. Walnuts
d. Tomatoes

8. Which picture best shows how ripe fruit affects man?

a. A sad person
b. A healthy person
c. A sick person
d. Two boys fighting

9. Which picture shows what is most important for fruit to grow and ripen?

a. A woman
b. A field
c. A farmer
d. The sun

REMEMBER, IF YOU HAVE QUESTIONS ABOUT THE PICTURES, YOU MAY ASK ME WHAT THEY ARE.

Questions to be Asked on the Concept SEED

1. What picture shows seeds?

   a. Small stones
   b. Kernels of corn
   c. Plant sprouts breaking through the ground
   d. A bunch of grapes

2. Which picture shows something seeds do by themselves?

   a. Seeds sprouting
   b. A man planting seeds
   c. Seeds boiling in a pot on a stove
   d. Seeds being eaten by a bird

3. Which picture makes you think of seeds?

   a. Meat
   b. Plants
   c. Cloth
   d. Leather

4. Which picture shows two kinds of seeds?

   a. An avocado seed and an egg in a nest
   b. Small pebbles and peanuts
   c. An orange with seeds and green peas
   d. Acorns and bird's eggs

5. Look at the baseball in the first square. Notice how big it is. Which pair of circles best shows how big and how small seeds may be?

   a. A baseball 2 1/2" in diameter
   b. Two circles 2 1/2" in diameter
   c. One circle 1" in diameter and one 2 1/2" in diameter
   d. One circle 1/8" in diameter and one 3 1/2" in diameter

6. Which picture is shaped like most seeds?

   a. A rectangle
   b. An oval shape
   c. A triangle
   d. A long line

7. Which picture does not show a seed?

a. A coconut
b. Bird's eggs
c. An apple cut in half with seeds
d. Lima beans

8. Which picture shows a use of seeds?

a. A coat
b. A pane of glass
c. A plate with corn, peas, and beans on it
d. Several pieces of wood

9. Which picture shows what there must be before we have new seeds?

a. A man
b. A tractor
c. A butterfly
d. Plants

Questions to be Asked on the Concept PLANET

1. Which picture shows a planet?

a. The sun
b. The earth
c. Stars at night
d. A quarter moon

2. Which picture best shows how a planet acts or behaves?

a. A planet shooting straight forward
b. A planet falling downward
c. A planet spinning
d. A motionless planet

3. Which picture makes you think of a planet?

a. A sphere
b. A rectangle
c. A triangle
d. A half circle

4. Which picture shows two planets?

a. The earth and the moon
b. The earth and Saturn
c. The earth and the sun
d. The earth and a burning comet

5. Which pair of circles best show how small and how large planets may be?
   - a. Two circles 2" in diameter
   - b. One circle 2 1/2" in diameter and one 2" in diameter
   - c. One circle 1/2" in diameter and one 3" in diameter
   - d. Two circles 3/4" in diameter
6. Which picture shows the main type or kind of material in a planet?
   - a. Clouds
   - b. Lumber
   - c. Igneous rock
   - d. Block of ice
7. Which picture does not show a planet?
   - a. The earth
   - b. The sun
   - c. Saturn
   - d. Mars
8. Which picture shows what a planet would do to a rock falling towards it?
   - a. A planet repelling a comet falling towards it
   - b. A planet pulling a comet towards it
   - c. A planet getting out of the way of the falling comet
   - d. A planet sending out fire to burn up the falling comet
9. Which picture shows something needed by a planet?
   - a. A sun
   - b. A moon
   - c. A cloud
   - d. A pond of water

Questions to be Asked on the Concept EARTH

1. Which picture shows the earth?
   - a. Saturn
   - b. The earth
   - c. A moon
   - d. Mars
2. Which picture best shows how the earth acts or behaves?
   - a. The earth shooting upwards
   - b. The earth falling through space
   - c. The earth being motionless
   - d. The earth spinning in its orbit

3. Which picture makes you think of the earth?

a. Water with waves on it
b. A man on a tractor cultivating a field of corn with mountains in the background
c. A cloud
d. A night sky with stars shining

4. Which picture shows two views of the earth?

a. The earth and the moon
b. The earth and Saturn
c. The earth and Venus
d. A sphere of the Western Hemisphere and a sphere of the Eastern Hemisphere

5. Which picture best describes the surface of the earth?

a. A large area covered with water with some level land and mountains
b. A ball of water
c. A ball of level land
d. A globe with nothing but mountains

6. Which picture is the most like the shape of the earth?

a. A square
b. A circle
c. A crumpled ball
d. An egg shape

7. Which picture does not show a view of the earth?

a. View of the Western Hemisphere
b. A polar view of the Arctic
c. A solid land mass of a hemisphere
d. View of the Eastern Hemisphere

8. Which picture shows what man must do to get enough food from the earth?

a. Man playing ball
b. Man working
c. Man sleeping
d. Man begging

9. Which picture shows what the earth needs to continue as it is?

a. The sun
b. A man
c. A comet
d. A building

REMEMBER, IF YOU HAVE QUESTIONS ABOUT THE PICTURES, YOU MAY ASK ME WHAT THEY ARE.

Questions to be Asked on the Concept SOIL

1. Which picture shows soil?

a. A pile of leaves
b. A furrow of open soil in a field
c. A pile of small pebbles
d. A pile of small twigs

2. It is raining in the first picture. A puddle of water is forming. In picture two, it has stopped raining and the puddle is running off into a stream. In picture three, it has stopped raining and as time passes, the puddle gets smaller. In picture four, the sun is helping to dry up the puddle after it stopped raining. Which picture (two, three, or four) best shows how the soil will affect the puddle of water?

3. Which picture makes you think of soil?

a. A plant
b. A man
c. A crumbling rock
d. A pond of water

4. Which picture shows two piles of soil?

a. A pile of soil and a large rock
b. A pile of soil and a pile of coal
c. A pile of red clay and a pile of black mud
d. A pile of soil and a pile of rocks

5. If the circle in the first square is as big as your fist is, then which circle in two, three, or four best shows how big a grain of soil is?

a. Circle 2 3/4" in diameter
b. Circle 2" in diameter
c. Circle 1" in diameter
d. Circle 1/4" in diameter

6. Which picture shows the usual colors of soil?

a. A square of black, red, and sandy white
b. A square of dark brown, purple, and blue
c. A square of green, blue, and red
d. A square of orange, purple, and black

7. Which picture does not show soil?

a. A pile of sand
b. A pile of black soil
c. A pile of red clay
d. A pile of flour

8. Which picture shows what soil helps give man?

a. Several kinds of food
b. Several jewels
c. A pond of water
d. Several metal pipes

9. Which picture best shows from where new soil would come?

a. A running stream of water
b. The wind blowing grass
c. Rocks falling down a mountainside
d. Rain

Questions to be Asked on the Concept METAL

1. Which picture shows something made of metal?

a. A copper penny
b. A jade drop
c. A piece of ivory
d. A column of marble

2. Which picture shows what metal will do for electricity?

a. A piece of metal stopping the flow of electricity
b. A piece of metal letting the electricity pass by it
c. A piece of metal with the electricity passing through it
d. A piece of metal chasing the electricity

3. Which picture makes you think of metal?

a. A greenhouse
b. A brick house
c. A cement highway
d. A factory

4. Which picture shows two kinds of metal?

a. A piece of gold and a bar of iron
b. A piece of aluminum and a piece of ivory
c. A tin can and a rubber tire
d. A ball of silver and a petrified rock

5. Which picture best shows how thin and how thick metal may be?

a. A box 1/4" high and a box 1 3/4" high

b. Two straight lines

c. A box 1/8" high and a box 2" high

d. A box 1 1/2" high and an irregular rectangle

6. Which picture best shows how most metals look or appear?

a. A shiny piece of metal

b. A rusty piece of metal

c. A cracked piece of metal

d. A red piece of metal

7. Which picture is not a picture of metal?

a. A lead pipe

b. A sheet of tin

c. A copper tube

d. A rubber hose

8. Which picture shows how man uses metal?

a. A cartoon of metal hurting man

b. Cartoon showing metals serving man by becoming parts of machines

c. A cartoon showing metals directing a man working

d. A cartoon showing metal being eaten by a man

9. Which picture shows what is needed if metal is to be used?

a. A stream of water

b. Rain

c. Wind blowing over the land

d. A miner

Questions to be Asked on the Concept MACHINE

1. Which picture shows a machine?

a. A man floating on a log

b. A man using a hand-operated pulley to life a heavy object

c. A tent stake supporting a tent rope

d. A rolling boulder knocking down a young tree

2. Which picture best shows what machines do?

a. A tractor pulling a load of hay
b. A cartoon of a tractor sleeping
c. A cartoon of tractors playing
d. A cartoon of a tractor resting in a rocking chair

3. Which picture makes you think of machines?

a. A plant
b. A glass of water
c. A plug in a wall socket
d. A grasshopper

4. Which picture shows two machines?

a. An airplane and a stork carrying a baby
b. A motor boat in water and a man floating on a log
c. A man driving a car and a boy riding a bicycle
d. A washing machine and a tub full of water

5. Which set of circles best shows how small and how large machines may be?

a. Three circles 1/2" in diameter
b. One circle 1/2" in diameter, one 1 1/2" in diameter, and one 2 1/2" in diameter
c. Two circles 1 1/2" in diameter
d. One circle 1 1/2" in diameter and one 2 1/2" in diameter

6. Which picture best shows what material used in building machines look like?

a. A rock
b. A crooked stick
c. A pile of rocks
d. A ball of metal

7. Which picture does not show a machine?

a. A loaded truck
b. A loaded ship
c. A loaded dolly
d. A donkey carrying a load

8. Which picture best shows how machines help man?

a. A pulley lifting a heavy load
b. A man lifting a heavy log
c. A woman washing at a creek
d. An Indian planting seeds

9. Which picture shows what machines need to operate or run?

a. The sun, moon, and stars
b. A can of gasoline, an electric cord and plug, and a flexed muscle
c. A rock, pile of soil, and a pool of water
d. A pile of lumber, several leaves, and a piece of cloth

Questions to be Asked on the Concept ELECTRICITY

1. Which picture shows where you would expect to find electricity?

a. A vase
b. A car battery
c. A wrist watch
d. A fire

2. Which picture shows something electricity does without the help of man?

a. Street lights
b. A dam on a river
c. Lightning
d. An electric light bulb

3. Which picture makes you think of electricity?

a. A zig-zag line
b. A straight line
c. A square
d. An irregular figure

4. Which picture shows how much electricity you can see?

a. A zig-zag line 1/4" long
b. A zig-zag line 1" long
c. A zig-zag line 3" long
d. A blank square

5. Which picture shows two uses of electricity by man?

a. An electric train, electric lights, and lightning
b. A boy standing under a street light by a fire
c. A man listening to an electric radio while lighting a pipe
d. A woman using an electric mixer on a table

2. Which picture best shows what machines do?

a. A tractor pulling a load of hay
b. A cartoon of a tractor sleeping
c. A cartoon of tractors playing
d. A cartoon of a tractor resting in a rocking chair

3. Which picture makes you think of machines?

a. A plant
b. A glass of water
c. A plug in a wall socket
d. A grasshopper

4. Which picture shows two machines?

a. An airplane and a stork carrying a baby
b. A motor boat in water and a man floating on a log
c. A man driving a car and a boy riding a bicycle
d. A washing machine and a tub full of water

5. Which set of circles best shows how small and how large machines may be?

a. Three circles 1/2" in diameter
b. One circle 1/2" in diameter, one 1 1/2" in diameter, and one 2 1/2" in diameter
c. Two circles 1 1/2" in diameter
d. One circle 1 1/2" in diameter and one 2 1/2" in diameter

6. Which picture best shows what material used in building machines look like?

a. A rock
b. A crooked stick
c. A pile of rocks
d. A ball of metal

7. Which picture does not show a machine?

a. A loaded truck
b. A loaded ship
c. A loaded dolly
d. A donkey carrying a load

8. Which picture best shows how machines help man?

a. A pulley lifting a heavy load
b. A man lifting a heavy log
c. A woman washing at a creek
d. An Indian planting seeds m

3. Which picture makes you think of skin?

a. A tablecloth over something on a table
b. A hole in the ground
c. A cake with the icing removed
d. A big rock

4. Which picture shows two kinds of skin?

a. Human skin and cloth
b. Human skin and scales
c. Hair and feathers
d. A snake skin and an alligator hide

5. Feel the skin on your arm. How thick do you think it is? Which line best shows how think your skin is?

a. A rectangle 1" thick
b. A rectangle 1/4" thick
c. A rectangle 1/2" thick
d. A rectangle 3/4" thick

6. Which picture shows how many layers skin has?

a. Skin with one layer
b. Skin with four layers
c. Skin with three layers
d. Skin with five layers

7. Which picture does not show skin?

a. Alligator hide
b. Tree bark
c. Leather
d. Snake skin which has been shed

8. Which picture makes you think of what our skin does for us?

a. A cartoon of skin covering a muscle
b. A cartoon of skin uncovering a muscle
c. A cartoon of skin carrying pails of blood
d. A cartoon of skin washing bones

9. Which picture shows what we must do to keep our skin alive and healthy?

a. A boy changing clothes
b. A boy eating a balanced meal
c. A boy bathing
d. A boy sleeping in a chair

Questions to be Asked on the Concept BACTERIA

1. Which picture shows bacteria?

   a. Bacilli
   b. Straight lines
   c. Curvical sketches
   d. Small ants

2. Which picture shows something bacteria do?

   a. A cartoon of bacteria flying
   b. A cartoon of bacteria walking
   c. A cartoon of bacteria using their flagella to move in a liquid
   d. A cartoon of bacteria sleeping

3. Which picture makes you think of bacteria?

   a. A burning lamp
   b. A microscope
   c. An open book
   d. A baby playing with blocks

4. Which picture shows two kinds of bacteria?

   a. A bacterium and a small flea
   b. A bacterium and a small rod
   c. A bacterium and a small ant
   d. A bacterium and a spirilla

5. Which picture shows what you would see if you looked for bacteria without a microscope?

   a. A circle 1/4" in diameter
   b. A circle 1 1/4" in diameter
   c. A circle 2 1/2" in diameter
   d. A blank picture

6. Which picture shows drawings shaped like bacteria?

   a. Rod shaped, round, and spiral
   b. Triangles
   c. Squares
   d. Rectangles

7. Which picture does not show bacteria?

   a. Bacilli
   b. Cocci
   c. Tiny insect eggs
   d. Spirilla

8. Which picture shows where bacteria have been?

   a. A board with termite holes in it
   b. A piece of cheese with holes in it
   c. A leaf which insects have eaten holes in
   d. An apple with a worm hole in it

9. Which picture best shows the type of place bacteria need to grow in?

   a. A block of ice
   b. A dog's warm, moist mouth
   c. A blow torch with flames
   d. A sealed can of fruit

Questions to be Asked on the Concept CELL

1. Which picture shows a cell?

   a. A circle
   b. A circle with sketches in it
   c. A typical animal cell
   d. A rectangle with sketches in it

2. Which picture shows something cells do?

   a. A cartoon of a cell blowing up another cell like a balloon
   b. A cell dividing
   c. A cartoon of a cell sleeping
   d. A cartoon of a cell crawling

3. Which picture makes you think of all kinds of cells?

   a. A big shade tree and a dog in the grass
   b. A desert with no animal life
   c. A mountain without any kind of life
   d. A car

4. Which picture shows two cells?

   a. A circle and a rectangle with sketches in them
   b. A rectangle with sketches in in it
   c. A circle with sketches in it and a cell
   d. An animal and a plant cell

5. Pretend that the first circle is the size of a dime. Which circle in two, three, or four best shows how large a cell is?

a. A circle 2" in diameter
b. A circle 1/8" in diameter
c. A circle 2" in diameter
d. A circle 3/4" in diameter

6. Which picture best shows how the inside of a cell looks?

a. A cell with a round nucleus
b. A cell with a square nucleus
c. A cell without a nucleus
d. An empty rectangle

7. Which picture does not show a cell?

a. A plant cell
b. A nerve cell
c. A paramecium
d. A drawing shaped like a muscle cell without a nucleus

8. Which picture best shows what cells do to fuel taken from food we eat?

a. A cell freezing it - cartoon
b. A cell mixing it with water - cartoon
c. A cell burning it - cartoon
d. A cell pushing it away - cartoon

9. Which picture shows what we must do to give the cells of our body fuel?

a. A boy taking a bath
b. A boy playing ball
c. A boy mending a fence
d. A boy eating food

APPENDIX B

SCALOGRAM ANALYSIS FOR ALL GRADES

Relations or Statements

	Concurrence		Distinctness		Appurtenance		Dimensional		Self-Activity		Equivalence		Reaction		Association		Functional dependence			
	20		20		20		20		20		20		20		20		20			
	credit: 15-20	no credit: 0-14	credit: 15-20	no credit: 0-14	credit: 15-20	no credit: 0-14	credit: 15-20	no credit: 0-14	credit: 15-20	no credit: 0-14	credit: 15-20	no credit: 0-14	credit: 15-20	no credit: 0-14	credit: 15-20	no credit: 0-14	credit: 15-20	no credit: 0-14	scores	errors
	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O		
6-1	X		X		X		X		X		X		X		X		X		9	0
6-2	X		X		X		X		X		X		X		X		X		9	0
6-3*	X		X		X		X		X		X		X		X		X		9	0
6-4	X		X		X		X		X		X		X		X		X		9	0
6-5*	X		X		X		X		X		X		X		X		X		9	0
6-6*	X		X		X		X		X		X		X		X		X		9	0
6-7	X		X		X		X		X		X		X		X		X		9	0
6-8	X		X		X		X		X		X		X		X		X		9	0
6-9	X		X		X		X		X		X		X		X		X		9	0
6-10*	X		X		X		X		X		X		X		X		X		9	0

rltns.	1		2		3		4		5		6		7		8		9		sc.	er.
6-11	X		X		X		X		X		X		X		X		X		9	0
6-12*	X		X		X		X		X		X		X		X		X		9	0
6-13	X		X		X		X		X		X		X		X		X		9	0
6-14	X		X		X		X		X		X		X		X		X		9	0
6-15*	X		X		X		X		X		X		X		X		X		9	0
6-16*	X		X		X		X		X		X		X		X		X		9	0
6-17*	X		X		X		X		X		X		X		X		X		9	0
3-18*	X		X		X		X		X		X		X		X		X		9	0
6-19*	X		X		X		X		X		X		X		X			0	8	0
6-20*	X		X		X		X		X		X		X		X			0	8	0
6-21*	X		X		X		X		X		X		X		X			0	8	0
6-22	X		X		X		X		X		X		X		X			0	8	0
6-23	X		X		X		X		X		X		X		X			0	8	0
6-24*	X		X		X		X		X		X		X		X			0	8	0
3-25*	X		X		X		X		X		X		X		X			0	8	0
**1-26*	X		X		X		X		X		X		X		X			0	8	0
1-27*	X		X		X		X		X		X		X		X			0	8	0
6-28*	X		X		X		X		X		X		X			0	X		8	1
6-29*	X		X		X		X		X		X		X			0	X		8	1
6-30	X		X		X		X		X		X		X			0	X		8	1
6-31*	X		X		X		X		X		X		X			0	X		8	1

**First grade subjects' scores are based upon these criteria:
Credit: 12-20 correct
No credit: 0-11 correct

rltns.	1		2		3		4		5		6		7		8		9		sc.	er.
6-32*	X		X		X		X		X		X		X			O	X		8	1
6-33*	X		X		X		X		X		X		X			O	X		8	1
6-34	X		X		X		X		X		X		X			O	X		8	1
6-35*	X		X		X		X		X		X		X			O	X		8	1
1-36*	X		X		X		X		X		X		X			O	X		8	1
1-37*	X		X		X		X		X		X		X			O	X		8	1
6-38*	X		X		X		X		X		X			O	X		X		8	2
6-39	X		X		X		X		X		X			O	X		X		8	2
6-40	X		X		X		X		X		X			O	X		X		8	2
6-41*	X		X		X		X		X		X			O	X		X		8	2
6-42*	X		X		X		X		X		X			O	X		X		8	2
3-43*	X		X		X		X		X		X			O	X		X		8	2
6-44*	X		X		X		X		X			O	X		X		X		8	3
6-45*	X		X		X		X		X			O	X		X		X		8	3
1-46*	X		X		X		X		X			O	X		X		X		8	3
3-47*	X		X		X		X		X			O	X		X		X		8	3
6-48	X		X		X		X			O	X		X		X		X		8	4
1-49*	X		X		X		X			O	X		X		X		X		8	4
6-50*	X		X		X			O	X		X		X		X		X		8	5
6-51*	X		X		X			O	X		X		X		X		X		8	5
1-52*	X		X		X			O	X		X		X		X		X		8	5

rltns.	1		2		3		4		5		6		7		8		9		sc.	er.
6-53	X		X			O	X		X		X		X		X		X		8	6
6-54	X		X			O	X		X		X		X		X		X		8	6
3-55*	X			O	X		X		X		X		X		X		X		8	7
3-56		O	X		X		X		X		X		X		X		X		8	8
6-57*	X		X		X		X		X		X		X			O		O	7	0
6-58*	X		X		X		X		X		X		X			O		O	7	0
6-59	X		X		X		X		X		X		X			O		O	7	0
6-60*	X		X		X		X		X		X		X			O		O	7	0
6-61	X		X		X		X		X		X		X			O		O	7	0
3-62*	X		X		X		X		X		X		X			O		O	7	0
3-63*	X		X		X		X		X		X		X			O		O	7	0
1-64*	X		X		X		X		X		X		X			O		O	7	0
6-65	X		X		X		X		X		X			O	X			O	7	1
6-66*	X		X		X		X		X		X			O	X			O	7	1
6-67*	X		X		X		X		X		X			O	X			O	7	1
6-68	X		X		X		X		X		X			O	X			O	7	1
1-69*	X		X		X		X		X		X			O		O	X		7	1
6-70	X		X		X		X		X		X			O		O	X		7	1
6-71	X		X		X		X		X			O		O	X		X		7	2
6-72	X		X		X		X		X			O	X			O	X		7	2
6-73*	X		X		X		X		X			O	X			O	X		7	2

rltns.	1		2		3		4		5		6		7		8		9		sc.	er.
6-74*	X		X		X		X		X			O	X			O	X		7	2
6-75*	X		X		X		X		X			O	X		X			O	7	2
6-76*	X		X		X		X		X			O	X		X			O	7	2
3-77	X		X		X		X		X			O	X		X			O	7	2
3-78	X		X		X		X		X			O	X		X			O	7	2
1-79*	X		X		X		X		X			O	X		X			O	7	2
6-80*	X		X		X		X			O	X		X			O	X		7	3
3-81	X		X		X			O		O	X		X		X		X		7	4
6-82*	X			O	X		X		X		X		X			O	X		7	6
6-83	X			O		O	X		X		X		X		X		X		7	6
6-84*	X		X		X		X		X		X			O		O		O	6	0
1-85	X		X		X		X		X		X			O		O		O	6	0
1-86*	X		X		X		X		X		X			O		O		O	6	0
6-87*	X		X		X		X		X			O		O	X			O	6	1
6-88*	X		X		X		X		X			O	X			O		O	6	1
6-89	X		X		X		X		X			O	X			O		O	6	1
6-90*	X		X		X		X		X			O		O		O	X		6	1
3-91*	X		X		X		X		X			O	X			O		O	6	1
3-92	X		X		X		X		X			O	X			O		O	6	1
1-93	X		X		X		X		X			O		O	X			O	6	1
1-94*	X		X		X		X		X			O		O		O	X		6	1

rltns.	1		2		3		4		5		6		7		8		9		sc.	er.
6-95	X		X		X		X			O	X			O	X			O	6	2
6-96*	X		X		X		X			O		O	X		X			O	6	2
6-97	X		X		X		X			O		O	X		X			O	6	2
6-98	X		X		X		X			O		O	X		X			O	6	2
6-99*	X		X		X		X			O	X		X			O		O	6	2
6-100	X		X		X		X			O	X		X			O		O	6	2
6-101	X		X		X		X			O	X		X			O		O	6	2
6-102	X		X		X		X			O		O	X			O	X		6	2
3-103*	X		X		X		X			O	X			O	X			O	6	2
3-104*	X		X		X		X			O	X			O	X			O	6	2
1-105*	X		X		X		X			O	X			O	X			O	6	2
1-106*	X		X		X		X			O	X		X			O		O	6	2
6-107	X		X		X			O		O	X		X		X			O	6	3
6-108	X		X		X			O		O	X		X		X			O	6	3
6-109*	X		X		X			O	X		X			O	X			O	6	3
6-110*	X		X		X			O	X			O		O	X		X		6	3
1-111*	X		X		X			O	X		X			O	X			O	6	3
1-112*	X		X		X			O	X		X			O	X			O	6	3
1-113*	X		X		X			O	X		X		X			O		O	6	3
1-114	X		X		X			O	X		X		X			O		O	6	3
1-115*	X		X		X			O	X		X		X			O		O	6	3

rltns.	1		2		3		4		5		6		7		8		9		sc.	er.
1-116*	X		X		X			O	X		X		X			O		O	6	3
1-117*	X		X		X			O		O	X			O	X		X		6	3
1-118	X		X		X			O	X		X			O		O	X		6	3
6-119	X			O	X		X		X		X		X			O		O	6	5
3-120*	X			O	X		X		X		X			O	X			O	6	5
3-121*	X			O	X		X		X		X			O	X			O	6	5
3-122*		O	X		X		X		X		X			O	X			O	6	6
3-123	X		X		X		X		X			O		O		O		O	5	0
3-124*	X		X		X		X		X			O		O		O		O	5	0
1-125*	X		X		X		X		X			O		O		O		O	5	0
6-126	X		X		X		X			O		O	X			O		O	5	1
6-127	X		X		X		X			O		O	X			O		O	5	1
3-128*	X		X		X		X			O		O	X			O		O	5	1
1-129*	X		X		X		X			O	X			O		O		O	5	1
1-130	X		X		X		X			O	X			O		O		O	5	1
1-131*	X		X		X		X			O		O		O		O	X		5	1
6-132	X		X		X			O		O		O	X		X			O	5	2
6-133	X		X		X			O		O		O	X		X			O	5	2
6-134*	X		X		X			O		O	X		X			O		O	5	2
3-135	X		X		X			O	X			O	X			O		O	5	2
3-136	X		X		X			O	X		X			O		O		O	5	2

rltns.	1		2		3		4		5		6		7		8		9		sc.	er.
3-137	X		X		X			O	X		X			O		O		O	5	2
3-138*	X		X		X			O	X			O	X			O		O	5	2
3-139	X		X		X			O	X			O		O		O	X		5	2
1-140	X		X		X			O		O	X			O	X			O	5	2
1-141	X		X		X			O	X			O	X			O		O	5	2
1-142*	X		X		X			O		O		O	X		X			O	5	2
1-143*	X		X		X			O		O		O	X		X			O	5	2
1-144	X		X		X			O		O		O		O	X		X		5	2
6-145*	X		X			O	X		X			O		O	X			O	5	3
6-146*	X		X			O	X		X			O	X			O		O	5	3
6-147*	X		X			O	X		X			O	X			O		O	5	3
6-148	X		X			O		O	X			O	X		X			O	5	3
3-149	X		X			O		O	X			O	X		X			O	5	3
3-150*	X		X			O		O	X			O	X		X			O	5	3
3-151*	X		X			O	X		X		X			O		O		O	5	3
3-152*	X		X			O	X		X			O		O	X			O	5	3
3-153*	X		X			O	X		X		X			O		O		O	5	3
1-154	X		X			O		O		O	X		X			O	X		5	3
1-155*	X		X			O		O		O	X		X		X			O	5	3
6-156	X			O	X		X		X			O	X			O		O	5	4
6-157*	X			O	X		X			O	X		X			O		O	5	4

rltns.	1	2	3	4	5	6	7	8	9	sc.	er.
1-158*	X	O	X	X	O	X	O	X	O	5	4
1-159*	X	O	O	X	X	O	X	O	X	5	4
3-160	O	X	X	O	X	O	O	X	X	5	5
3-161	O	X	O	X	X	O	X	O	X	5	5
3-162	O	X	X	X	O	X	O	O	X	5	5
1-163	O	X	X	X	O	O	X	X	O	5	5
6-164*	X	X	X	X	O	O	O	O	O	4	0
3-165	X	X	X	X	O	O	O	O	O	4	0
3-166*	X	X	X	X	O	O	O	O	O	4	0
1-167*	X	X	X	X	O	O	O	O	O	4	0
1-168*	X	X	X	X	O	O	O	O	O	4	0
1-169	X	X	X	X	O	O	O	O	O	4	0
6-170*	X	X	X	O	X	O	O	O	O	4	1
6-171	X	X	X	O	O	O	O	O	X	4	1
3-172	X	X	X	O	O	O	O	X	O	4	1
3-173*	X	X	X	O	O	O	X	O	O	4	1
1-174	X	X	X	O	X	O	O	O	O	4	1
1-175*	X	X	X	O	O	O	X	O	O	4	1
1-176	X	X	X	O	O	O	X	O	O	4	1
1-177*	X	X	X	O	O	X	O	O	O	4	1
1-178	X	X	X	O	O	X	O	O	O	4	1

rltns.	1		2		3		4		5		6		7		8		9		sc.	er.
1-179	X		X		X			O	X			O		O		O		O	4	1
1-180	X		X		X			O		O		O		O	X			O	4	1
6-181	X		X			O	X			O		O		O	X			O	4	2
6-182*	X		X			O	X			O	X			O		O		O	4	2
6-183*	X		X			O	X			O		O	X			O		O	4	2
6-184	X		X			O		O		O	X		X			O		O	4	2
3-185	X		X			O		O		O		O	X		X			O	4	2
3-186	X		X			O	X			O		O		O	X			O	4	2
3-187	X		X			O	X			O		O		O	X			O	4	2
3-188	X		X			O	X			O	X			O		O		O	4	2
3-189*	X		X			O	X			O		O		O	X			O	4	2
3-190*	X		X			O	X			O	X			O		O		O	4	2
3-191*	X		X			O		O		O	X			O		O		O	4	2
1-192	X		X			O		O	X			O		O	X			O	4	2
1-193	X		X			O		O	X			O		O	X			O	4	2
1-194	X		X			O	X			O		O		O		O	X		4	2
1-195*	X		X			O		O	X			O	X			O		O	4	2
1-196	X		X			O		O		O	X			O	X			O	4	2
1-197*	X		X			O	X			O		O	X			O		O	4	2
1-198	X		X			O		O		O		O		O	X		X		4	2
1-199	X		X			O		O		O		O		O	X		X		4	2

rltns.	1		2		3		4		5		6		7		8		9		sc.	er.
3-200	X			O	X		X			O		O		O	X			O	4	3
1-201	X			O	X			O		O	X		X			O		O	4	3
1-202	X			O		O		O	X		X			O	X			O	4	3
3-203		O	X		X		X		X			O		O		O		O	4	4
1-204		O		O		O	X		X		X			O	X			O	4	4
3-205*	X		X		X			O		O		O		O		O		O	3	0
3-206	X		X		X			O		O		O		O		O		O	3	0
3-207*	X		X		X			O		O		O		O		O		O	3	0
1-208*	X		X		X			O		O		O		O		O		O	3	0
1-209*	X		X		X			O		O		O		O		O		O	3	0
1-210*	X		X		X			O		O		O		O		O		O	3	0
1-211*	X		X		X			O		O		O		O		O		O	3	0
1-212*	X		X		X			O		O		O		O		O		O	3	0
1-213*	X		X		X			O		O		O		O		O		O	3	0
6-214*	X		X			O	X			O		O		O		O		O	3	1
3-215*	X		X			O	X			O		O		O		O		O	3	1
3-216*	X		X			O	X			O		O		O		O		O	3	1
3-217*	X		X			O	X			O		O		O		O		O	3	1
3-218	X		X			O	X			O		O		O		O		O	3	1
3-219*	X		X			O	X			O		O		O		O		O	3	1
3-220	X		X			O		O	X			O		O		O		O	3	1

rltns.	1		2		3		4		5		6		7		8		9		sc.	er.
3-221*	X		X			O		O		O		O	X			O		O	3	1
3-222	X		X			O		O		O		O	X			O		O	3	1
1-223*	X		X			O	X			O		O		O		O		O	3	1
1-224	X		X			O	X			O		O		O		O		O	3	1
1-225*	X		X			O	X			O		O		O		O		O	3	1
1-226	X		X			O	X			O		O		O		O		O	3	1
1-227*	X		X			O		O	X			O		O		O		O	3	1
1-228	X		X			O		O		O	X			O		O		O	3	1
1-229*	X		X			O		O		O	X			O		O		O	3	1
1-230*	X		X			O		O		O		O		O	X			O	3	1
6-231*	X			O	X			O		O		O		O	X			O	3	2
6-232*	X			O	X			O		O		O	X			O		O	3	2
3-233	X			O	X			O		O		O		O	X			O	3	2
3-234*	X			O	X			O		O		O		O		O	X		3	2
3-235	X			O		O		O	X		X			O		O		O	3	2
3-236	X			O		O		O		O		O	X		X			O	3	2
3-237	X			O	X		X			O		O		O		O		O	3	2
3-238*	X			O	X			O	X			O		O		O		O	3	2
1-239*	X			O		O	X			O		O	X			O		O	3	2
1-240*	X			O	X			O		O		O		O	X			O	3	2
1-241	X			O	X		X			O		O		O		O		O	3	2

rltns.	1		2		3		4		5		6		7		8		9		sc.	er.
1-242	X			O	X			O		O	X			O		O		O	3	2
6-243*		O		O	X		X			O		O		O		O	X		3	3
3-244*		O		O	X		X		X			O		O		O		O	3	3
3-245*		O		O	X		X		X			O		O		O		O	3	3
3-246		O		O	X		X		X			O		O		O		O	3	3
3-247*		O	X		X			O	X			O		O		O		O	3	3
1-248*		O	X			O	X			O	X			O		O		O	3	3
1-249*		O	X			O	X		X			O		O		O		O	3	3
6-250*	X		X			O		O		O		O		O		O		O	2	0
3-251	X		X			O		O		O		O		O		O		O	2	0
3-252	X		X			O		O		O		O		O		O		O	2	0
3-253*	X		X			O		O		O		O		O		O		O	2	0
3-254*	X		X			O		O		O		O		O		O		O	2	0
3-255	X		X			O		O		O		O		O		O		O	2	0
3-256	X		X			O		O		O		O		O		O		O	2	0
3-257*	X		X			O		O		O		O		O		O		O	2	0
3-258	X		X			O		O		O		O		O		O		O	2	0
3-259	X		X			O		O		O		O		O		O		O	2	0
3-260*	X		X			O		O		O		O		O		O		O	2	0
3-261	X		X			O		O		O		O		O		O		O	2	0
3-262*	X		X			O		O		O		O		O		O		O	2	0

rltns.	1		2		3		4		5		6		7		8		9		sc.	er.
1-263*	X		X			0		0		0		0		0		0		0	2	0
1-264	X		X			0		0		0		0		0		0		0	2	0
1-265*	X		X			0		0		0		0		0		0		0	2	0
1-266	X		X			0		0		0		0		0		0		0	2	0
1-267	X		X			0		0		0		0		0		0		0	2	0
1-268	X		X			0		0		0		0		0		0		0	2	0
1-269	X		X			0		0		0		0		0		0		0	2	0
1-270*	X		X			0		0		0		0		0		0		0	2	0
1-271	X		X			0		0		0		0		0		0		0	2	0
1-272	X		X			0		0		0		0		0		0		0	2	0
1-273	X		X			0		0		0		0		0		0		0	2	0
6-274	X			0	X			0		0		0		0		0		0	2	1
3-275	X			0		0		0		0	X			0		0		0	2	1
3-276*	X			0		0		0		0		0		0	X			0	2	1
3-277	X			0	X			0		0		0		0		0		0	2	1
3-278*	X			0		0		0		0	X			0		0		0	2	1
3-279	X			0		0		0		0		0	X			0		0	2	1
3-280	X			0	X			0		0		0		0		0		0	2	1
3-281	X			0		0	X			0		0		0		0		0	2	1
3-282*	X			0		0		0	X			0		0		0		0	2	1
3-283*	X			0		0		0	X			0		0		0		0	2	1

ritns.	1		2		3		4		5		6		7		8		9		sc.	er.
3-284	X			O		O	X			O		O		O		O		O	2	1
1-285*	X			O		O	X			O		O		O		O		O	2	1
1-286	X			O	X			O		O		O		O		O		O	2	1
1-287*	X			O		O	X			O		O		O		O		O	2	1
6-288		O		O	X		X			O		O		O		O		O	2	2
3-289		O		O	X			O		O		O		O	X			O	2	2
3-290		O	X			O		O		O		O	X			O		O	2	2
3-291*		O		O	X			O		O		O		O		O	X		2	2
3-292		O		O	X			O	X			O		O		O		O	2	2
6-293	X			O		O		O		O		O		O		O		O	1	0
3-294	X			O		O		O		O		O		O		O		O	1	0
3-295	X			O		O		O		O		O		O		O		O	1	0
3-296	X			O		O		O		O		O		O		O		O	1	0
3-297	X			O		O		O		O		O		O		O		O	1	0
3-298*	X			O		O		O		O		O		O		O		O	1	0
3-299	X			O		O		O		O		O		O		O		O	1	0
1-300	X			O		O		O		O		O		O		O		O	1	0
1-301	X			O		O		O		O		O		O		O		O	1	0
1-302	X			O		O		O		O		O		O		O		O	1	0
3-303*		O		O		O		O	X			O		O		O		O	1	1
3-304*		O	X			O		O		O		O		O		O		O	1	1

rltns.	1		2		3		4		5		6		7		8		9		sc.	er.
3-305		O	X			O		O		O		O		O		O		O	1	1
3-306		O	X			O		O		O		O		O		O		O	1	1
1-307		O	X			O		O		O		O		O		O		O	1	1
1-308*		O		O		O	X			O		O		O		O		O	1	1
1-309		O	X			O		O		O		O		O		O		O	1	1
1-310		O		O	X			O		O		O		O		O		O	1	1
3-311		O		O		O		O		O		O		O		O		O	O	O
3-312		O		O		O		O		O		O		O		O		O	O	O
3-313		O		O		O		O		O		O		O		O		O	O	O
3-314		O		O		O		O		O		O		O		O		O	O	O
3-315		O		O		O		O		O		O		O		O		O	O	O
1-316		O		O		O		O		O		O		O		O		O	O	O
1-317*		O		O		O		O		O		O		O		O		O	O	O
1-318*		O		O		O		O		O		O		O		O		O	O	O
frqnc.	282	36	249	69	199	119	170	148	146	177	131	187	128	190	115	203	78	240	1499	477
% of X	.89		.78		.63		.54		.46		.41		.40		.36		.25		.52	
% of O	.11		.22		.37		.46		.54		.59		.60		.64		.75		.48	

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